COMPILED LECTURE

IN

ENGINEERING ECONOMY

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PREFACE

This manual is compilation of notes taken mainly from the book ‘Engineering Economy’ by Sullivan et al. a book recommended as text book for the subject ENGR 322 – Engineering Economics. Other notes were also taken from other sources which were reflected at the References. Useful websites are also found at the References where students can learn from their own. Most of the problem sets on first four chapters were also used.

This lecture note was started by Engr. Lorie Cabanayan when I was on study leave. She taught the subject for more than three years while I was taking my doctorate degree and she learn much on the subject. She retired early for family reasons and I know she is applying the principles she acquired on this subject on her business.

I recognize her decision to leave the College as trade-off for her family; a very just and right decision. I salute you!

Francis Cuaresma

CHAPTER I. INTRODUCTION TO ENGINEERING ECONOMICS

ENGINEERING ECONOMY/ECONOMICS DEFINED

- As defined by Arreola

Engineering economy is that branch of economics which involve the application of definite laws of economics, theories of investment and business practices to engineering problems involving cost.

It is also defined to be the study of economic theories and their application to engineering problems with concept of obtaining the maximum benefit at the least cost as a basis for decision.

It also involves the study of cost features and other financial data and their application in the field of engineering as a basis for decision.

- As defined by Kasner

Engineering economics is equated with practicality and economic feasibility. It is also the search for the recognition of alternatives which are then compared and evaluated in order to come up with the most practical design and creation.

- As defined by Sullivan, et al.

Engineering economy is the systematic evaluation of the economic merits of proposed solutions to engineering problems.

IMPORTANT USES OF ENGINEERING ECONOMY

1. Seeking new objectives for the application of engineering – An important use of engineering economy is to seek new objectives for engineering application. Engineers are constantly seeking new and wider application of their technical knowledge for the benefit of mankind and in line with this, engineering economy provides basic principles and laws.
2. Discovery of factors limiting the success of a venture or enterprise – upon knowing the objectives, next is to determine ways and means to attain such objectives. With Engineering Economy the so-called limiting factors which may hinder the success of a project are being discovered.
3. Comparison of alternatives as a basis for decision – The principles of engineering economy helps to point out the analysis of choosing the best alternatives on a quantitative basis.
4. Analysis of possible investment of capital – Engineering economy enables engineers to consider all aspects of investment from both the technical and financial viewpoints. It provides several patterns of analysis to determine rate of return, annual costs and pay out periods, which all serves as bases for decision.
5. Determination of bases for decision – Engineers' main concern is on future actions, that is on what to do and not on what has been accomplished. Decisions on future actions are more valid and accurate if the principles of engineering economy are correctly applied.

Origins of engineering economy. A civil engineer named Arthur Wellington in the later part of the 19th century made use of engineering economic analysis in building railroads in the U. S. In 1930, Eugene Grant published his book, Principles of Engineering Economy, which emphasized on techniques that depended on financial and actuarial mathematics.

What are the principles of engineering economy?

Principle 1. Develop the alternatives. The choice is among alternatives.
Principle 2. Focus on the differences. Only the difference in expected outcomes is considered.
Principle 3. Use a consistent viewpoint. Prospective outcomes of the alternatives, economic, etc. should be considered.
Principle 4. Use a common unit of measure. Using a common unit of measurement of the possible outcomes in comparing alternatives.
Principle 5. Consider all relevant criteria. Consider both monetary and other unit of measure in measurement of outcomes.
Principle 6. Make uncertainty explicit. Uncertainty is inherent in projecting future outcomes and should considered in their analysis and comparison.
Principle 7. Revisit your decisions. Projected results and decisions should be compared with actual results to improved the decision process.

The Engineering Economic Analysis Procedure

Steps:

1. Problem recognition, definition, and evaluation.
2. Development of the feasible alternatives.
3. Development of the cash flows for each alternative.
4. Selection of a criterion (or criteria).
5. Analysis and comparison of the alternative.
6. Performance monitoring and post evaluation results.

CHAPTER II. COST CONCEPTS AND DESIGN ECONOMICS

TERMINOLOGIES

Fixed cost – those that are unaffected by changes in activity level over a feasible range of operations for the capacity or capability available. (Insurance and taxes on facilities, general management and administrative salaries, license fees and interest costs of borrowed capital)

Variable cost – are those associated with an operation that vary in relation to changes in quantity of output or other measures of activity level. For the example, the cost of materials and labor used in a product or service are variable costs – because they vary with the number of output units even though the costs per unit stay the same.

Incremental cost (incremental revenue) – refers to the additional cost or revenue that will result for increasing the output of a system by one of more units. This is often quite difficult to determine in practice. Thus if to produce 100 units will cost P200, and the total cost for producing 110 units is P215, then the increment cost for additional 10 units is P15 or 1.50 per unit.

Recurring costs – costs that are repetitive and occur where an organization produces similar goods or services on a continuing basis. Variable cost are also recurring costs, because they repeat with each unit of output. Fixed cost that is paid on a repeatable basis is a recurring cost (ex. office space rental)

Non-recurring costs – are those that are not repetitive even though the total expenditures maybe cumulative over a relatively short period of time. Usually it involves the developing or establishing a capability or capacity to operate.

Direct cost – those that can be reasonably measured and allocated to a specific output or work (labor and materials).

Indirect cost – costs that are difficult to attribute or allocate to a specific output. They are costs allocated through a selected formula (such as proportional to direct labor hours or direct materials) to the outputs or work activities (ex. Cost of common tools, general supplies equipment maintenance).

Overhead cost – used to mean all expenditures that are not direct cost (administrative, insurance, taxes, electricity, general repairs)

Standard cost – representation cost per unit of output that are established in advance of actual production or service delivery. They are developed from anticipated direct labor hours, materials and overhead categories. Standard costs play an important role in cost control and other management functions like estimating future manufacturing costs.

Cash cost – cost that involves payment of cash.

Book cost – does not involve cash transaction; non-cash. The most common example of book cost is the depreciation. It is included in an analysis for it affects income taxes, which are cash flows.

Opportunity cost – is incurred because of the use of limited resources such that the opportunity to use those resources to monetary advantage in alternative use is foregone. It is the cost of the best rejected opportunity and is often hidden or implied.

Example of opportunity cost:

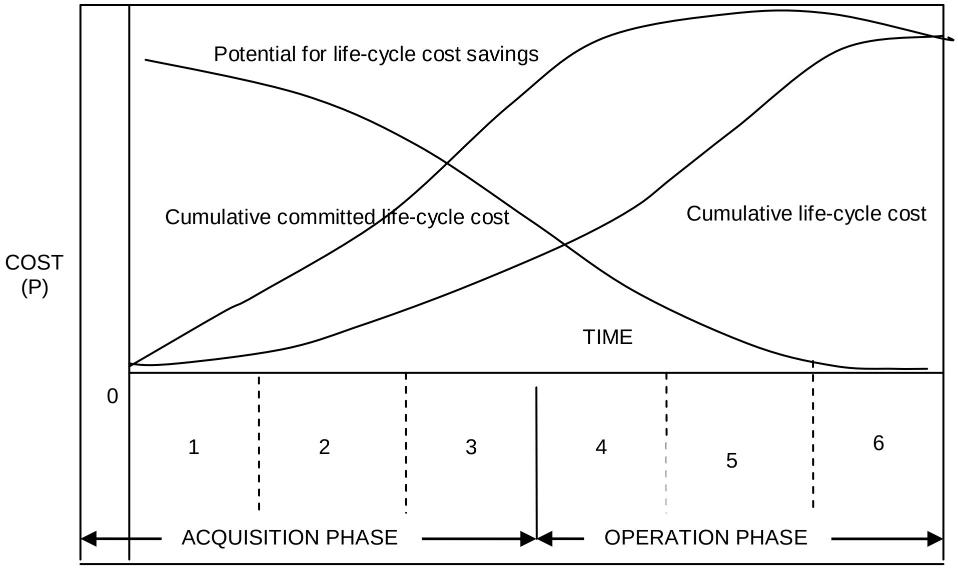
Consider a student who could earn P 5,000/ month or P60,000 for working during a year but chooses instead to go to school for a year and spend P35,000 to do so. The opportunity cost of going to school for that year is P95,000 (the 60,000 for the income gone and the P35,000 for the school expenses).

Sunk cost – is one that has occurred in the past and has no relevance to estimates of future costs and revenues related to an alternative course of action. It represents money which has been invested and which cannot be recovered due to certain reasons. A sunk cost is common to all alternatives and is not part of the future cash flows and can be disregarded in an engineering economic analysis.

Life cycle cost – refers to the summation of cost estimates from inception to disposal for both equipment and projects as determined by an analytical study and estimate of total costs experienced during their life. The objective of LCC analysis is to choose the most cost effective approach from a series of alternatives so the least long term cost of ownership is achieved.

LCC analysis helps engineers justify equipment and process selection based on total costs rather than the initial purchase price. Usually the cost of operation, maintenance, and disposal costs exceed all other costs many times over. Life cycle costs are the total costs estimated to be incurred in the design, development, production, operation, maintenance, support, and final disposition of a major system over its anticipated useful life span (DOE, 1995). The best balance among cost elements is achieved when the total LCC is minimized (Landers, 1996).

Figure 1. The Life Cycle Cost



1 = Needs assessment; definition of requirements
2 = Conceptual (preliminary) design; advanced development; prototype testing
3 = Detailed design; production or construction planning; facility and resource acquisition
4 = Production or construction
5 = Operation or customer use; maintenance and support
6 = Retirement and disposal

Life cycle begins with the identification of the economic need or want and ends with retirement and disposal activities. Life cycle is divided into two general time periods, the acquisition phase and the operation phase. And each phase is further subdivided into interrelated but different activity periods.

The figure shows the relative cost profiles for the life cycle. The greatest potential for achieving life-cycle cost savings is early in the acquisition phase. Savings on the life-cycle costs of a product is dependent on many factors. And here, effective engineering design and economic analysis during this phase are critical in maximizing potential savings. One aspect of cost-effective engineering design is the *minimizing of the impact of design changes* during the steps in the life cycle.

The cumulative committed life cycle cost curve increases rapidly during the acquisition phase. In general, approximately 80% of life cycle costs are “locked in” at the end of this phase by the decisions made during the requirements analysis and preliminary and detailed design. In contrast, as reflected by the cumulative life-cycle cost curve, only about 20% of actual costs occur during the acquisition phase, with about 80% being incurred during the operation phase.

One purpose of the life-cycle concept is to make explicit the interrelated effects of costs over the total life span for a product. The objective of the design process is to minimize the life cycle cost – while meeting other performance requirements.

Investment cost – first cost or cost incurred during the acquisition phase. It is the capital required for most of the activities in the acquisition phase.

Capital investment – series of expenditures over an extended period on a large construction project.

Working capital – refers to the funds required for current assets (equipment, facilities) that are needed for the start-up and support of operational activities.

Operation and maintenance cost – includes many of the recurring annual expense items associated with the operation phase of the life cycle. The direct and indirect costs of operation in *five primary resource areas,* 1) people 2) machines 3) materials 4) energy 5) information – are major parts of the costs in this category.

Disposal cost – includes those non recurring costs of shutting down the operation and the retirement and disposal of assets at the end of the life cycle. Ex. Costs associated with personnel, materials.

SOME ECONOMIC RELATIONSHIPS

Consumer and Producer Goods and Services

- Consumer goods and services are those products or services that are directly used by people to satisfy their wants. (Food, clothing, homes, cars, appliances, medical services, etc)
- Producer goods and services are used to produce consumer goods and services or other producer goods. (Machine tools, factory buildings, buses, etc.).

Producer goods and services are intermediate step or serve as a mean to satisfy human wants. The amount of producer goods needed is determined indirectly by the amount of consumer goods or services that are demanded by people.

Necessities and Luxuries

- Necessities are those products or services that are required to support human life and activities, that will be purchased in somewhat the same quantity even though the price varies considerably.
- Luxuries are those products or services that are desired by human and will be purchased if money available after the required necessities have been obtained.

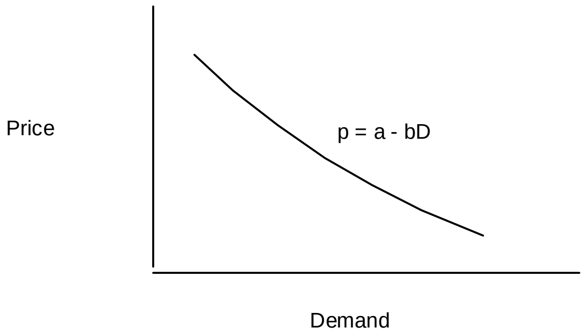
Demand

Demand is the quantity of a certain commodity that is bought at a certain price at a given place and time. Demand refers to how much (quantity) of a product or service is desired by buyers. The quantity demanded is the amount of a certain product people are willing to buy at a certain price.

Law of Demand – The demand for a commodity varies inversely as the price of the commodity, though not proportionately.

It states that if all other factors remain equal, the higher the price, the less people will demand a good. In other words, the higher the price, the lower the quantity demanded. The amount buyers purchase at a higher price is less because, as the price of goes up, so does the opportunity cost of buying that good: people will naturally avoid buying a product that is beyond their capacity to buy. The chart below shows that the curve is a downward slope:

Figure 2. General Price-demand Relationship



As the selling price per unit (p) is increased, there will be less demand (D) for the product, and as the selling price is decreased, the demand will increase. Expressing as a linear function:

Equation 1. $p = a - bD$; where a = the intercept on the price axis
b = the slope, the amount by which demand increases for each unit decrease in p

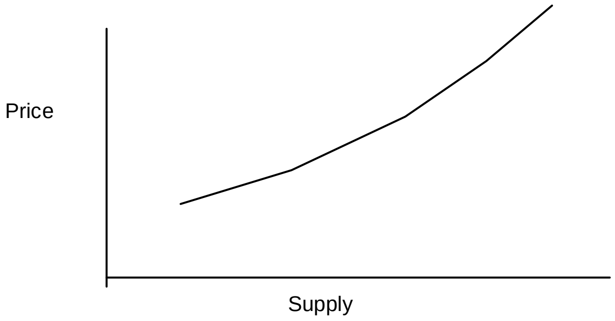
$$D = \frac{a - p}{b} \qquad (b \neq 0) \text{ ……………………………….. equation 2}$$

Supply

Supply is the quantity of a certain commodity that is offered for sale at certain price at a given place and time. It represents how much the market can offer.

Law of supply The supply of the commodity varies directly as the price of the commodity, though not proportionately.

Figure 3. General Price-supply Relationship



Opposite to the demand relationship, the supply relationship shows an upward slope. This means that the higher the price, the higher the quantity supplied. Producers supply more at a higher price because selling a higher quantity at a higher price offers greater revenues.

Time and Supply

Unlike the demand relationship, however, the supply relationship is a factor of time. Time is important to supply because suppliers must, but cannot always, react quickly to a change in demand or price. So it is important to try and determine whether a price change that is caused by demand will be temporary or permanent.

Supply and Demand Relationship

Now that we know the laws of supply and demand, let's turn to an example to show how supply and demand affect price.

Imagine that a special edition CD of your favorite band is released for $20. Because the record company's previous analysis showed that consumers will not demand CDs at a price higher than $20, only ten CDs were released because the opportunity cost is too high for suppliers to produce more. If, however, the ten CDs are demanded by 20 people, the price will subsequently rise because, according to the demand relationship, as demand increases, so does the price. Consequently, the rise in price should prompt more CDs to be supplied as the supply relationship shows that the higher the price, the higher the quantity supplied.

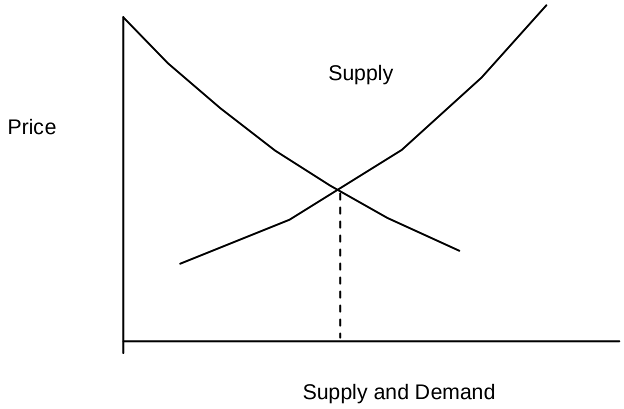
If, however, there are 30 CDs produced and demand is still at 20, the price will not be pushed up because the supply more than accommodates demand. In fact after the 20 consumers have been satisfied with their CD purchases, the price of the leftover CDs may drop as CD producers attempt to sell the remaining ten CDs. The lower price will then make the CD more available to people who had previously decided that the opportunity cost of buying the CD at $20 was too high.

The Law of Supply and Demand

The law of supply and demand may be stated as follows:

"Under conditions of perfect competition the price at which a given product will be supplied and purchased is the price that will result in the supply and the demand being equal."

Figure 4. Price-Supply- Demand Relationship



When supply and demand are equal (i.e. when the supply function and demand function intersect) the economy is said to be at equilibrium. At this point, the allocation of goods is at its most efficient because the amount of goods being supplied is exactly the same as the amount of goods being demanded. Thus, everyone (individuals, firms, or countries) is satisfied with the current economic condition. At the given price, suppliers are selling all the goods that they have produced and consumers are getting all the goods that they are demanding.

Competition, Monopoly, and Oligopoly

Perfect competition occurs in a situation where a commodity or services is supplied by a number of vendors and there is nothing to prevent additional vendors entering the market. There is no restriction against other vendors from entering the market. Buyers are free to buy from any vendor, and the vendors likewise are free to sell to anyone.

An opposite of perfect competition is Perfect monopoly which exist when a unique product or service is available from only a single vendor and that vendor can prevent the entry of all others into the market. Examples of monopolies are the services offered by Meralco electric pants throughout the country, the telephone companies and other public utilities, in which the sole right are being granted by the government.

Oligopoly exists when there are so few suppliers of a product or service that action by one will almost inevitable result in similar action by the others. Examples of oligopoly in the Philippines are the oil companies and manufacturers of soft drinks who hold franchises to produce drinks of foreign origin. Any change in price of anyone of them is usually accompanied by a similar change by the other competitors.

Utility

The focus of economics is to understand the problem of scarcity: the problem of fulfilling the unlimited wants of humankind with limited and/or scarce resources. Underlying the laws of demand and supply is the concept of utility, which represents the advantage or fulfillment a person receives from consuming a good or service. Utility, then, explains how individuals and economies aim to gain optimal satisfaction in dealing with scarcity.

Utility - is an abstract concept rather than a concrete, observable quantity. The units to which we assign an “amount” of utility, therefore, are arbitrary, representing a relative value. Total utility is the aggregate sum of satisfaction or benefit that an individual gains from consuming a given amount of goods or services in an economy. The amount of a person's total utility corresponds to the person's level of consumption. Usually, the more the person consumes, the larger his or her total utility will be. Marginal utility is the additional satisfaction, or amount of utility, gained from each extra unit of consumption.

Although total utility usually increases as more of a good is consumed, marginal utility usually decreases with each additional increase in the consumption of a good. This decrease demonstrates the **law of diminishing marginal utility**. Because there is a certain threshold of satisfaction, the consumer will no longer receive the same pleasure from consumption once that threshold is crossed.

In other words, total utility will increase at a slower pace as an individual increases the quantity consumed.

The Law of Diminishing Return

"When the use of one of the factors of production is limited, either in increasing cost or absolute quantity, a point will be reached beyond which an increase in the variable factors will result in a less than proportionate increase in output"

"When one of the factors of production is fixed in quantity or is difficult to increase, increasing the other factors of production will increase in a less than proportionate increase in output.

This law was originally applied in agriculture, correlating the input o men, fertilizers and other variable factors to the input in crops or harvest. Example: Increasing gradually the quantity of fertilizer for a fixed area of land will result in an increase in output up to a certain extent, beyond which the output will decrease or even become nil.

Total Revenue

The Total revenue, TR, that will result from a business venture during a given period is the product of the selling price per unit, p, and the number of units sold, D.

$$TR = \text{price x demand} = p * D \text{ .... Equation 3}$$

If the relationship between price and demand as given by equation 1 is used,

$$TR = (a - bD)D = aD - bD^2 \text{ ....Equation 4}$$

COST, VOLUME AND BREAKEVEN POINT RELATIONSHIPS

Break even analysis is a useful tool to study the relationship between fixed costs, variable costs, and returns. A **break even point** defines when an investment will generate a positive return can be determined graphically or with simple mathematics.

Quick Facts...

- A break-even point defines when an investment will generate a positive return.
- Fixed costs are not directly related to the level of production.
- Variable costs change in direct relation to volume of output.
- Total fixed costs do not change as the level of production increases.

Break-even analysis computes the volume of production at a given price necessary to cover all costs. Break-even price analysis computes the price necessary at a given level of production to cover all costs.

At any demand, D, **the total cost** is

$C_T = C_F + C_V$ ………………………. equation 5

Where: C_T = Total cost
C_F = Fixed cost
C_V = Variable cost

For linear relationship: $C_V = c_v . D$ …………………….. equation 6

where: c_v = is the variable cost per unit
D = is the total product produced or volume demanded

There are 2 scenarios in solving the breakeven points:

1st Scenario:

When total revenue (equation 5) and total cost as given by equations 5 and 6 are combined, the typical results as a function of demand is shown in Figure 5.

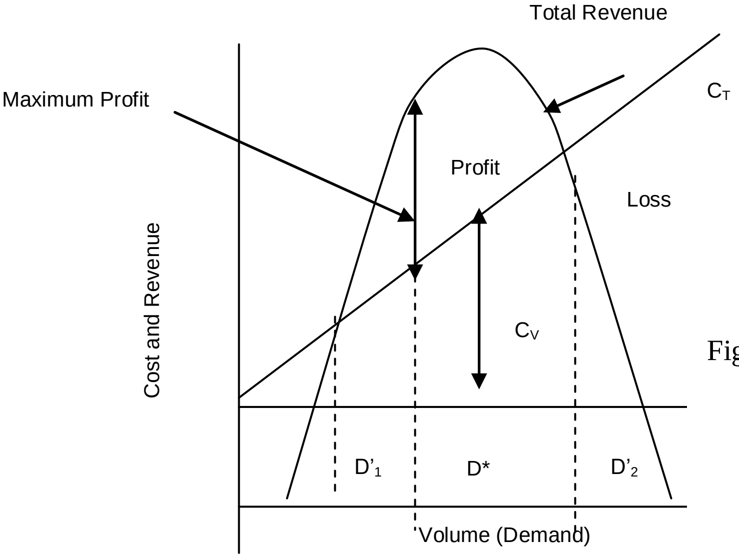


Figure 5. Combined cost and revenue functions, and break even points as functions of volume and their effect on typical profit

At break even point D'_1, total revenue is equal to total cost, and an increase in demand will result in a profit for the operation. Then at optimal demand, D*, profit is maximized. At breakeven point D'_2 , total revenue and total cost are again equal, but additional volume will result in an operating loss instead of a profit.

At any volume, D, Profit = total revenue – total costs

$= (aD - bD^2) - (C_F + c_vD)$

$= - bD^2 + (a - c_v) D - C_F$ ……………………… equation 7

Two conditions must be met in order for a profit to occur:

1. $(a - c_v) > 0$; that is, the price per unit that will result in no demand has to be greater than the variable cost per unit
2. Total revenue (TR) must exceed total cost (C_T) for the period involved.

If these 2 conditions were met, the optimal value of D that maximizes profit is

$$D^* = \frac{a - c_v}{2b}$$ ………………………….. equation 8

For Break even point:

Total revenue = total cost

$aD - bD^2 = C_F + c_vD$ => $-bD^2 + (a - c_v)\,D - C_F = 0$ …………………Equation 9

Equation 10 is a quadratic equation with one unknown (D), solving for breakeven points D'_1 and D'_2……

$$D' = \frac{-\,(a - c_v) + -\,[(a - c_v)^2 - 4(-b)\,(-C_F)]\ ½}{2(-b)}$$ ……………………. Equation 10

Sample problem:

A company produces an electronic timing switch that is used in consumer and commercial products made by several other manufacturing firms. The fixed cost (CF) is $73,000 per month, and the variable cost (cv) is $83 per unit. The selling price per unit is p = $180 – 0.02(D), based on Equation 1. For this situation (a) determine the optimal volume for this product and confirm that a profit occurs (instead of a loss) at this demand; and (b) find the volumes at which breakeven occurs; that is, what is the domain of profitable demand?

Solution:

(a) $D^* = \frac{a - cv}{2b} = \frac{\$180 - 83}{2(0.02)}$ = 2,425 units per month (from Equation 1)

Is $(a - c_v) > 0$?

($180 – 83) = $97, which is greater than 0.

And is (total revenue – total cost) > 0 for D* = 2,425 units per month?

$[\$180(2{,}425) - 0.02(2{,}425)^2] - [\$73{,}000 + 83(2{,}425] = \$44{,}612$

(b) Total revenue = total cost (break-even point)

$$D' = \frac{-\,(a - c_v) + -\,[(a - c_v)^2 - 4(-b)\,(-C_F)]^{½}}{2(-b)}$$ (From Equation 10)

$$D' = \frac{-97 +- [(97)2 - 4(-0.02)(-73{,}000)]^{½}}{2(-0.02)}$$

$$D'_1 = \frac{-97 + 59.74}{-0.04} = 932 \text{ units per month}$$

$$D'_2 = \frac{-97 - 59.74}{-0.04} = 3{,}918 \text{ per month}$$

Thus, the domain of profitable demand is 932 to 3,918 units per month

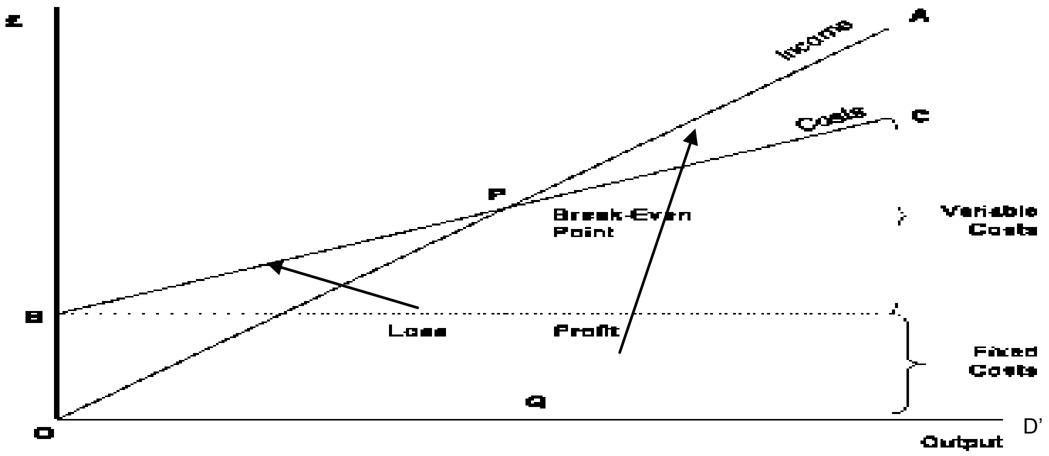


Figure 6. Typical Breakeven Chart with price (p) a constant

2nd Scenario

When the price per unit (p) for a product or service can be represented more simply as being independent of demand and is greater than variable cost per unit (c_V), a single breakeven point results. Assuming that the demand is immediately met, TR = p.D and using equations 5 and 6, the typical situation is shown in Figure 6.

Total fixed costs do not change as the level of production increases.

The total cost line is the sum of the total fixed costs and total variable costs.

The total income (Profit) line is the gross value of the output.

The key point (break-even point) is the intersection of the total cost line and the total income line (Point P). A vertical line down from this point shows the level of production necessary to cover all costs. Production greater than this level generates positive revenue; losses are incurred at lower levels of production.

Breakeven Point

Break even = Total revenue = Total cost
$= pD = C_F + C_V$
$= pD = C_F + c_V D'$
$D' = C_F / (p - c_V)$ .... Equation 11

Break Even = Fixed Cost / (Unit Price - Variable Unit Cost)

Sample problem:

An engineering consulting firm measures its output in a standard service hour unit, which is a function of the personnel grade levels in the professional staff. The variable cost (c_v) is \$62 per standard service hour. The charge-out rate [i.e., selling price (p)] is $1.38.c_v$ = \$85.56 per hour. The maximum output of the firm is 160,000 hours per year, and its fixed cost (C_F) is \$2,024,000 per year. For this firm, (a) what is the breakeven point in standard service hours and in percentage of total capacity and (b) what is the percentage reduction in the breakeven point (sensitivity) if fixed costs are reduced 10 percent; if variable cost per hour is reduced 10 percent; if both costs are reduced 10 percent; and if the selling price per unit is increased by 10 percent?

Solution:

(a) Total revenue = total cost

$$pD' = C_F + c_v D'$$

$$D' = \frac{C_F}{(p - c_v)}$$

$$D' = \frac{\$2{,}024{,}000}{(\$85.56 - \$62)} = 85{,}908 \text{ hours per year}$$

$$D' = 85{,}908 / 160{,}000 = 0.537 \text{ or } 53.7\% \text{ capacity}$$

(b) 10% reduction in C_F:

$$D' = \frac{0.9\,(\$2{,}024{,}000)}{(\$85.56 - \$62)} = 77{,}318 \text{ hours per year}$$

$$D' = 85{,}908 - 77{,}318 / 85{,}908 = 0.10 \text{ or } 10\% \text{ reduction in } D'$$

and 10% reduction in c_v:

$$D' = \frac{(\$2{,}024{,}000)}{[\$85.56 - 0.9\,(\$62)]} = 68{,}011 \text{ hours per year}$$

$$D' = 85{,}908 - 68{,}011 / 85{,}908 = 0.208 \text{ or } 20.8\% \text{ reduction in } D'$$

and 10% reduction in both C_F and c_v:

$$D' = \frac{0.9\,(\$2{,}024{,}000)}{[\$85.56 - 0.9\,(\$62)]} = 61{,}210 \text{ hours per year}$$

$$D' = 85{,}908 - 61{,}210 / 85{,}908 = 0.287 \text{ or } 28.7\% \text{ reduction in } D'$$

and 10% increase in p:

$$D' = \frac{(\$2{,}024{,}000)}{[1.1(\$85.56) - \$62]} = 63{,}021 \text{ hours per year}$$

$$D' = 85{,}908 - 63{,}021 / 85{,}908 = 0.266 \text{ or } 26.6\% \text{ reduction in } D'$$

Therefore, the breakeven point is more sensitive to a reduction in variable cost per hour than to the same percentage reduction in fixed cost, but reduced costs in both areas should be sought. And also breakeven point in this example is highly sensitive to the selling price per unit, p.

The breakeven point in an operating situation can be determined in 1) units of output 2) percentage utilization of capacity 3) sales volume (demand).

CHAPTER III. PRINCIPLES OF MONEY-TIME RELATIONSHIPS

TERMINOLOGIES

Capital – refers to wealth in the form of money or property that can be used to produce more wealth.

The Concept of Time Value of Money – “Money makes money”. This is true because if we invest money today, by tomorrow we will have accumulated more money that what we had originally invested. And also if you borrow money today you will have to pay in the future an amount that is larger that what you have originally owed. This change in the amount of money over a given time period is called *time value of money”.*

Equity capital – is owned by individuals who have invested their money or property in a business project or venture in the hope of receiving a profit and sometimes in exchange for a share of ownership in the company. Equity financing allows a business to obtain funds without incurring debt or having to repay a specific amount of money at a particular time.

Debt Capital – also called borrowed capital, is represented by funds borrowed by a business that must be repaid over a period of time, usually with interest. Debt financing can be either short-term, with full repayment due in less than one year, or long-term, with repayment due over a period greater than one year.

Return On Capital - measures of how effectively a company uses the money (borrowed or owned) invested in its operations.

Interest - The term "interest" is used to indicate the rent paid for the use of money. It is also used to represent the percentage earned by an investment in a productive operation. From the *lender's* point of view, the interest is the income produced by the money which he has lent. From the *borrower's* point of view, interest is the amount of money paid for the use of borrowed capital. The percentage of money charge as interest is called as interest rate.

Simple Interest

The interest is said to be *simple interest* if the interest to be paid is directly proportional to the length of time the amount or principal is borrowed. The *principal* is the amount of money borrowed or invested.

Total interest (I) is computed by the formula:

$$\mathbf{I = (P)\,(n)\,(i)}$$

where: P = principal amount lent or borrowed
n = number of interest period (ex. years)
i = interest rate per interest period

The total amount , F to be repaid at the end of N interest period is **F = P + I of F = P[1 + (n x i)]**

Sample Problems.

1. Suppose that P1,000 is borrowed at a simple interest rate of 18% per annum. At the end of one year, the interest would be:

   I = (P) (n) (i)
   I = 1,000 (1) (0.18) = P 180

2. Michelle invested $5000.00 in mutual fund with the interest rate of 4.8%. How much interest would she earn after 2 years?

   P = $5000.00 ; i= 4.8% ; n= 2

   I = (P) (n) (i)
   I = ($5000.00)(4.8%)(2) = $480.00

   Hence, Michelle would earn $480 after 2 years.

3. Jeff has one savings account with the interest rate of 3.3%, and one money market account with the interest rate of 5.1% in a bank. If he deposits $1,200.00 to the savings account, and $1,800.00 to the money market account, how much money will he have after 6 years?

Savings account:	Money market account:
P = $1,200.00	P = $1,800.00
i = 3.3%	i = 5.1%
n= 6	n = 6
I = ($1,200.00) (3.3%) (6)]	= ($1,800.00)[1+(5.1%)(6)]
I = 237.60	= ($1,800.00)(1.306)
	= $2,350.80
F = P + I	Total amount:
F = $1,200.00 + 237.60	$1437.60 + $2350.80
F = $1,437.60	= $3,788.40
	Hence, Jeff will have $3,788.40 after 6 years.

Compound Interest

- Whenever the interest charge for any interest period is based on the remaining principal amount plus any accumulated interest chargers up to the beginning of that period, the interest is said to be *compou*nd.
- *Compound interest* calculations apply to investments where the amount of interest is calculated on the present balance of the account.

Sample Problem.

For instance, if you invested $100 in a bank with an interest rate of 10% compounded annually (once per year), then in the first year of your investment you would earn $10. If this were simple interest, you would continue to earn $10 per year for the period of your investment. However, since the interest is compounded, you earn interest on your interest. The amount of compound interest for the first interest period is the same as for simple interest. However, for further interest periods, the amount of compound interest increases to an amount greater than simple interest.

To illustrate:

	Simple Interest	Compound Interest
Year 1	$100 * 10% = **$10**	$100 * 10% = **$10**
Year 2	$100 * 10% = **$10**	$110 * 10% = **$11**
Year 3	$100 * 10% = **$10**	$121 * 10% = **$12.10**
Total Interest	**$30**	**$33.10**

From the illustration above, you can see that under simple interest payments, a yearly sum of $10 is gained through interest. For each year of the loan period, $10 is earned. However, under compound interest payments, the yearly interest is added to the principle for the next period. This has the effect of increasing interest earned each year for the duration of the period (note: in example above, $33.10 earned from compound interest versus $30 earned from simple interest).

NOTATION AND CASH FLOW DIAGRAMS

Notations used in formulas for compound interest formulas

i = interest rate per interest period
N = number of compounding periods
P = present sum of money; the equivalent worth of one or more cash flows at a reference point in time called the present
F = future sum of money; the equivalent worth of one or more cash flows at a reference point in time called the future
A = end-of-period cash flows in a uniform series continuing for a specified number of periods; starting at the end of the first period and continuing through the last period

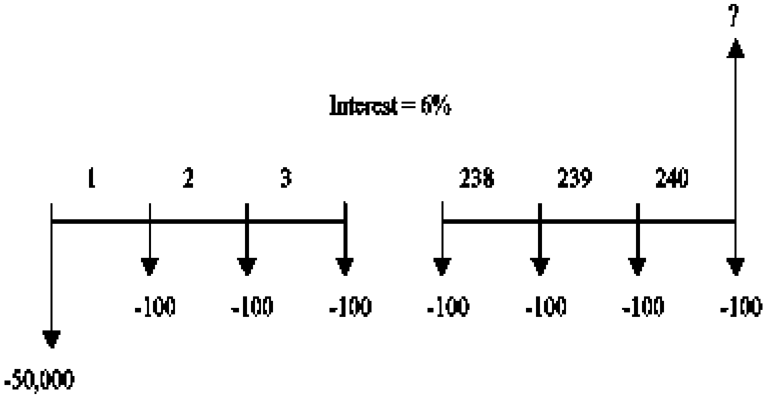
Cash Flow Diagram

- Cash flow is the difference between total cash coming (inflows or cash receipts) and total cash going out (outflows or cash disbursements) for a given period of time. Cash flow provides a means for planning the most effective use of your cash.
- A cash flow diagram is a picture of a financial problem that shows all cash inflows and outflows plotted along a horizontal time line. It is used to visualize cash flow: individual cash flows are presented as vertical arrows along a horizontal time scale.

The cash flow diagram employs several conventions:

1. The horizontal line is a *time scale*, with progression of time moving from left to right divided into equal periods such as days, months, or years.
2. The arrows signify cash flows and are placed at the end of the period. Funds that you pay out such as savings deposits or lease payments are negative cash flows that are represented by downward arrows Funds that you receive such as proceeds from a mortgage or withdrawals from a saving account are positive cash flows represented by upward arrows.
3. The cash flow diagram is dependent on the point of view (e.g. lender versus borrower viewpoint).

Example: You are 40 years old and have accumulated $50,000 in your savings account. You can add $100 at the end of each month to your account which pays an annual interest rate of 6% compounded monthly. Will you be able to retire in 20 years?



The time line is divided into 240 monthly periods (20 years times 12 payments per year) since the payments are made monthly and the interest is also compounded monthly. The $50,000 that you have now (present value) is a negative cash outflow since you will treat it as though you were just now depositing it into the account. It is represented with a downward pointing arrow with its base at the beginning of the first period. The 240 monthly $100 deposits are also negative outflows represented with downward pointing arrows placed at the end of each period. Finally you will withdraw some unknown amount (the future value) after 20 years. Represent this positive inflow with an upward pointing arrow with its base at the very end of the last period.

This diagram was drawn from your point of view. From the bank's point of view, the present value and the series of deposits are positive cash inflows, and the final withdrawal of the future value will be a negative outflow.

INTEREST FORMULAS FOR DISCRETE CASH FLOWS

Single Cash Flows / Payments

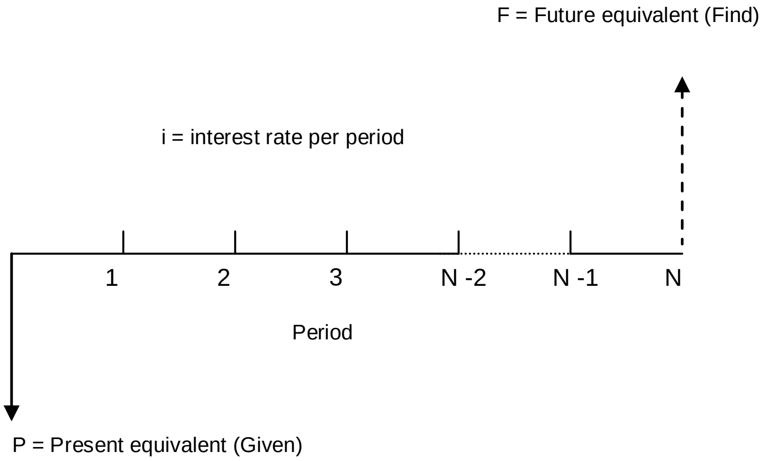

F = Future equivalent (Find)
i = interest rate per period
1
2
3
N -2
N -1
N
Period
P = Present equivalent (Given)

Figure shows a cash flow diagram involving a present single sum, P and a future single sum F, separated by N periods with interest at i% per period. The dashed arrow indicates the quantity to be determined.

Finding F When Given P

$$F = P(1 + i)^N$$

The quantity $(1+i)^N$ is commonly called the *single payment compound amount factor*. The functional symbol of $(1+i)^N$ is (F/P, i%, N). Therefore the equation can be expressed as

$F = P\ (F/P, i\%, N)$ where the factor in parentheses is read "find F given P at i% interest per period for N interest periods."

Problem. Find the compound amount of US$ 1 000 in 4 years at 8% interest compounded annually.

$$F = P(1 + i)^N$$
$$F = 1\,000 \times (1 + 0.08)^4 = 1\,000 \times 1.3605 = \underline{\text{US\$ 1,360.5}}$$

Finding P When Given F

$$P = F\ (1 / 1 + i)^N = F(1+i\%)^{-N}$$

The quantity $(1+i)^{-N}$ is called the *single payment present worth factor*. The functional symbol for this factor is (P/F, i%, N). Hence

$$P = F\ (P/F,\ i\%,\ N)$$

Problem. How much should be invested now (at present time) at 8% compound interest per year, in order to receive US$ 1360.5 within 4 years; or what is the present equivalent worth of US$ 1 360.5 to be received four years in the future?

$$P = 1,360.5 \text{ x } (1/1+.08^{)-4} = 1,360.5 \times (1/1.3605) = 1\ 360.5 \times 0.73503 = \underline{\text{US\$ } 1,000}$$

Uniform Series

Uniform series mean uniform amount of money, A, occurring at the end of each period for n periods with interest at i% per period. A uniform series is often called *annuity*.

Annuity - is a bunch of structured payments or equal payments made regularly, like every month or every week.

Other assumptions:

1. P (present worth) occurs at one interest period before the first A.
2. F (future worth) occurs at the same time as the last and n interest periods after P.
3. A (annual worth) occurs at the end of periods 1 through N, inclusive.

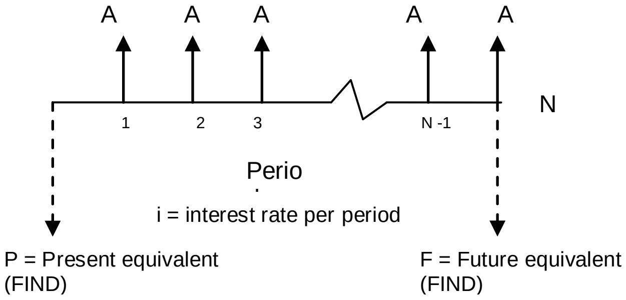


Figure shows a general cash flow diagram relating uniform series (ordinary annuity) to the present equivalent and future equivalent values.

Finding F When Given A

$$F = A \left[\frac{(1+i)^N - 1}{i} \right]$$

The quantity {[(1 + i)^N – 1] / i} is called the *uniform series compound amount factor*. The functional symbol for this factor is (F/A, i%, N). Hence,

$F = A\ (F/A,\ i\%,\ N)$

Problem. Example: If you deposit $10,000 in a bank every year for 18 years at interest rate 8%. Then this amount becomes

$F = 10{,}000 \text{ x } \{[(1 + 0.08)^{18} - 1] / 0.08]\} = \underline{\$374;\ 502}:$

What this amount will be if the interest rate is 10%? What if N = 20?

Finding P When Given A

$$P = A \left[\frac{(1 + i)^N - 1}{i(1 + i)^N} \right]$$

The equation in bracket is called the *uniform series present worth factor*. And the functional symbol for this factor is (P/A, i%, N). Therefore:

$P = A\ (P/A,\ i\%,\ N)$

Problem. If a certain machine undergoes a major overhaul now, its output can be increased by 20% - which translates into additional cash flow of $20,000 at the end of each year for five years. If i = 15% per year, how much can we afford to invest to overhaul this machine?

$P = 20{,}000 \text{ x } \{[(1 + 0.15)^5 - 1] / 0.15\ (1 + 0.15)^5 = \$20{,}000\ (3.3522) = \underline{\$67{,}044}$

Problem. You are running a bank. A customer agrees to pay you $100,000 each year with annual interest rate of 10% for 5 years. How much money will you lend to him?

$P = 100{,}000 \text{ x } (P/A,\ i\%,\ N) = \underline{\$379{,}080}$

Finding A When Given F

$$A = F \left[\frac{i}{(1 + i)^N - 1} \right]$$

This is the relation for finding the amount, A, of a uniform series of cash flows occurring at the end of N interest periods that would be equivalent to its future equivalent value occurring at the end of the last period. The quantity in bracket is called the *sinking fund factor* and the functional symbol for this factor is (A/F, i%, N). Hence, $A = F\ (A/F,\ i\%,\ N)$

Problem. How much do you need to invest every year in a bank with an interest rate of 8% in order to yield $1 million in 30 year?

$A = 1{,}000{,}000 \text{ x } (A/F,\ 8\%;\ 30) = \underline{\$8{,}827}$

How much this will be if the interest rate is 10%?

Problem. An enterprising student is planning to have personal savings totaling \$1,000,000 when she retires at age 65. She is now 20 years old. If the annual interest rate will average 7% over the next 45 years on her savings account, what equal end-of-year amount must she save to accomplish her goal.

A = \$1,000,000 (A/F, 7%, 45) = \$1,000,000 (0.0035)= \$3,500

Finding A When Given P

$$A = P \left[\frac{i\,(1 + i)^N}{(1 + i)^N - 1} \right]$$

The quantity in bracket is called the *capital recovery factor* and the functional symbol for this factor is (A/P, i%, N). Therefore,

A = P (A/P, i%, N)

Problem. Example: You want to buy an apartment at the price of 4 million Hong Kong dollars. You will do this with a mortgage from a bank at the annual interest rate 8% for 30 years. What is your annual payment?

A = 4,000,000 (A/P, 8%, 30) = \$355,200
(\$29,600 per month).

What if the interest rate is 6%?
What if the mortgage is for 20 years? 10 years?

Table 1. Discrete Compounding Interest Factors and Symbols

To Find:	**Given:**	**Factor by which to multiply "Given"**	**Factor Name**	**Factor Functional Symbol**
For Single Cash Flow				
F	P	$(1 + i)^N$	Single payment compound amount	(F/P, i%, N)
P	F	$1 / (1 + i)^N$	Single payment present worth	(P/F, i%, N)
For Uniform series (annuities)				
F	A	$[(1 + i)^N – 1] / i$	Uniform series compound amount	(F/A, i%, N)
P	A	$[(1 + i)^N – 1] / i(1 + i)^N$	Uniform series present worth	(P/A, i%, N)
A	F	$i / [(1 + i)^N – 1]$	Sinking Fund	(A/F, i%, N)
A	P	$i(1 + i)^N / [(1 + i)^N – 1]$	Capital recovery	(A/P, i%, N)

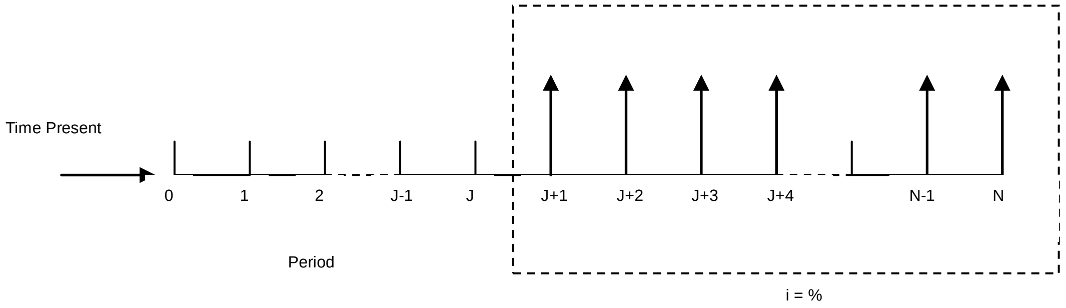
INTEREST FORMULAS FOR DISCRETE COMPOUNDING AND DISCRETE CASH FLOWS

Discrete Compounding – it means that the interest is compounded at the end of each finite length period, such as month or a year. The formulas also assume discrete (lump-sum) cash flows spaced at the end of equal time intervals of a cash flow diagram.

Deferred Annuities (Uniform Series)

Ordinary Annuity – is one where the equal payments are made at the end of each payment period starting from the first period.

Deferred Annuity – is one where the payment of the first amount is deferred a certain number of periods after the first.

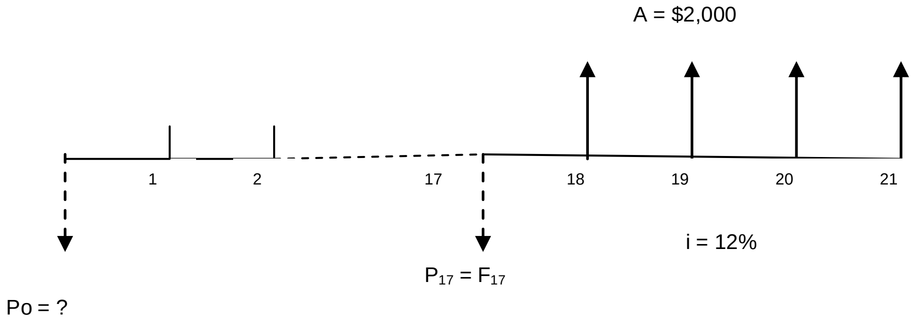


If the annuity is deferred J periods (J<N), the entire framed ordinary annuity has been forward from "time present", or "time 0", by J periods. Since the annuity deferred for J periods, the first payment is made at the end of period (J + 1), assuming that all periods involved are equal in length.

The present equivalent at the end of period J of an annuity with cash flow of amount A is A (P/A, i%, N-J). The present equivalent of the single amount A (P/A, i%, N-J) as of time 0 will then be

A (P/A, i%, N-J) (P/F, i%, J)

Problem. Suppose that a father, on the day his son is born wishes to determine what lump amount would have to be paid into an account bearing interest of 12% per year to provide withdrawals of \$2,000 on each of the son's 18th, 19th, 20th, and 21st birthdays.



Solution: N = 21 ; J = 17

$P_{17} = A\ (P/A, 12\%, 4) = \$2{,}000\ (3.0373) = \underline{\$6{,}074.60}$
$P_0 = F_{17}(P/F, 12\%, 17) = \$6{,}074.60\ (0.1456) = \underline{\$884.46}$

NOMINAL AND EFFECTIVE INTEREST RATES

Nominal Interest Rate - Nominal means "in name only". This is sometimes called the quoted rate or basic annual interest. It is the stated rate of interest applied to your investment.

Periodic Rate - The amount of interest you are charged each period, like every month.

Effective interest rate - the actual annual interest rate that accrues, after taking into consideration the effects of compounding (when compounding occurs more than once per year). The rate that you actually get charged on an annual basis. Remember you are paying interest on interest.

To illustrate: Consider a principal amount of $1,000 to be invested for three years at a nominal rate of 12% compounded semi-annually. The interest earned during the first six months would be:
$\$1{,}000 \times (0.12/2) = \$60$

The interest earned during the second six months would be
$\$1{,}060 \times (0.12/2) = 63.60$

Then total interest earned during the year is
$\$60.00 + \$63.20 = \$123.60$

The *effective annual interest rate* for the entire year is
$(\$123.60 / \$1{,}000) \times 100 = \underline{12.36\%}$

The relationship between effective annual interest, i, and nominal interest r, is

$\mathbf{i = (1 + r/M)^M - 1}$ where M is the number of compounding periods per year and r is expressed in decimal.

Problem: A credit card company charges an interest rate of 1.375 per month on the unpaid balance of all accounts. The annual interest rate they claim is 12 x 1.375% = 16.5%. What is the effective rate of interest per year being charged by the company?

$i = (1 + 0.165/12)^{12} - 1$
$= 0.1781$ or 17.81% per year

Interest Problems With Compounding More Often Than Once Per Year

Single Amounts

If a nominal interest rate is quoted and the number of compounding periods per year and number of years are known, any problem involving future amounts, annual, or present equivalent values can be calculated by straightforward use of equations $F = P(1 + i)^N$ and $i = (1 + r/M)^M - 1$ respectively.

Problem. Suppose that a \$100 lump-sum amount is invested for 10 years at a nominal rate of 6% compounded quarterly. How much is it worth at the end of the tenth year?
Solution: There are 4 compounding periods per year, or a total of 4 x 10 = 40 periods. The interest rate per interest period is 6%/4 = 1.5%.

$F = P\ (F/P, 1.5\%, 40) = \$100.00\ (1.015)^{40} = \$100.00\ (1.814) = \underline{\$181.40}$

Other solution: Using $i = (1 + r/M)^M - 1$

$i = (1 + 6/10)^{10} - 1 = 6.14\%$
$F = P\ (F/P, 6.14\%, 10) = \$100.00\ (1.0614)^{10} = \underline{\$181.40}$

Problem. At a certain interest rate compounded semi-annually, P2,000 will amount to 6,500 in 10 years. What is the amount at the end of 15 years?

Solution: Solve first for the interest
For 10 years: $F = P\ (1+i)^N$ $N = 10\ (2) = 20$ periods
$6{,}500 = 2{,}000\ (1+i)^{20}$
$3.25 = (1+i)^{20}$
$3.25^{1/20} = 1+i$
$1.06 = 1+i$
$i = 1.06 - 1$
$i = 0.06$ or 6%
For 15 years: $F = 2{,}000\ (1.06)^{30}$
$F = 11{,}486.98$

Uniform Series

Problem. Suppose that one has a bank loan for \$10,000, which is to be repaid in equal end-of-month installments for five years with a nominal interest rate of 12% compounded monthly. What is the amount of each payment?

Solution: Number of installments = 5 x 12 = 60, interest rate per month is 12%/12 = 1%.

$A = P(A/P, 1\%, 60) = 10{,}000\ (0.0222) = \underline{\$222}$

Problem. A father wishes to provide P4,000 for his son on his 21st birthday. How much should he deposit every 6 months in a savings bank which pay 3% compounded semi-annually, if the first deposit is made when the son is $3^{1/2}$ years old?

N = 17.5 years (2) = 35 periods i = 3/2 = 1.5%

A = F(A/F, 1.5%, 35) = 4,000 [0.015 / $(1+0.015)^{35}$ -1]
= 4,000 (0.015/0.684)
= 4,000 (0.022)
= P87.73

Interest Problems With Cash Flows Less Often Than Compounding Periods

Problem. Suppose that there exists a series of 10 end-of-year receipts of $1,000 each, and it is desired to compute their equivalent worth as one of the tenth year is the nominal interest rate is 12% compounded quarterly.

Solution. Interest = 12/4 = 3% per quarter, but the uniform series cash flows do not occur at the end of each quarter.

1st Procedure: Compute an equivalent cash flow for the time interval that corresponds to the stated compounding frequency.

A = F(A/F,3%,4)
= $1,000 (0.2390)
= $239 at the end of each quarter is equivalent to $1,000 at the end of each year.

Therefore, the future equivalent at the end of 10th quarter is: N = 10(4) = 40 periods

F = A(F/A,3%,40)
= $239 (75.4012) = $18,021

2nd Procedure:

Get the effective interest rate: i = $(1+r/M)^M$ -1 = $(1+12/4)^4$ – 1 = 0.1255 or 12.55%

F = A (F/A, 12.55%,10) = $1,000 (F/A, 12.55, 10) = $18,022

CHAPTER IV DEPRECIATION

TERMINOLOGIES

Depreciation – is defined as the decrease in the value of a property, such as machinery, equipment, building or other structure, due to the passage of time. This is due to many reasons, from deterioration and obsolescence to impending retirement. Depreciation cost depends upon the physical and economic life of the equipment and its first cost.

Physical life of an equipment is the length of time during which it is capable of performing the function for which it was designed and manufactured.

Economic life of an equipment is the length of time during which it will operate at a satisfactory unit.

Basis (or cost basis) is the cost of acquiring an asset (purchase price) including normal costs of making the asset serviceable. Also referred to as unadjusted cost.

Adjusted (cost) basis refers to changes to the original cost basis of a property caused by various types of improvements or casualty losses.

VALUE is the present worth (PW) of all the future profits that are to be received though ownership of a particular property.

Market Value (MV) is what will be paid by a willing buyer to a willing seller for a property where each has equal advantage and is under no compulsion to buy or sell.

Salvage or residual value (SV) is the price that can be obtained from the sale of the property after it has been used. It is the best estimate of an asset's net market value at the end of its useful life. If used in depreciation calculations, it is referred to as estimated salvage (ES), representing an asset's terminal value.

Useful life sometimes referred to as **depreciable life**, is the expected period of time that a property will be used in a trade or business or to produce income. It is not how long the property will last but how long the owner expects to productively use it.

Book Value (BV) is the worth of a property as shown on the accounting records of a company. Ordinarily, it means the original cost of the property less all amounts that have been charged as depreciation expense.

Scrap Value is the amount the property would sell if disposed off as a junk.

Depreciable property – property for which depreciation is allowed under federal, state or municipal income tax laws and regulations.

A property is depreciable if it meets all of the following basic requirements:

1. It must be used in business or held to produce income.
2. It must have a determinable useful life, and the life must be longer than one year.

3. It must be something that wears out, decays, gets used up, becomes obsolete or loses value from natural causes.
4. It is not inventory, stock in trade, or investment property.

Examples of depreciable assets are cars, computers, office furniture, machines, buildings, and significant additions or improvements (as opposed to repairs) to these kinds of property.

Requirements of a Depreciation Method:

1. It should be simple
2. It should recover capital
3. Ensure that the book value will be reasonably close to the market value at any time
4. The method must be acceptable by the BIR

DEPRECIATION METHODS:

1. **Straight-Line (SL) Method**
   - It is the simplest and most widely used depreciation method.
   - It assumes that the loss in value is directly proportional to the age of the property.
   - In the straight line method the depreciation base is **evenly** allocated over the lifetime of the asset, resulting in equal annual depreciation
   - It does not need annuity tables.
   - It does not take into account the interest or profit earned on the accumulated depreciation fund. Likewise O and M cost are disregarded.

N = depreciable life of an asset in years
B = cost basis
d_k= annual depreciation reduction in year k ($1 \leq k \leq N$)
BV_k= book value at the end of year k
SV_N = estimated salvage value at the end of year N
d^*_k = cumulative depreciation through year k

$$d_k = (B - SV_N) / N$$

$$d^*_k = kd_k \text{ for } 1 \leq k \leq N$$

$$BV_k = B - d^*_k$$

Sample problem 1. A new electrical saw for cutting small pieces of lumber in a furniture manufacturing plant has a cost basis of $4,000 and a 10-year depreciable life. The estimated SV of the saw is zero at the end of 10 years. Determine the annual depreciation amounts using the straight-line method. Tabulate the annual depreciation amounts and the book value of the saw at the end of each year.

Sample computation:

$$d_k = (B - SV_N) / N = (4{,}000 - 0) / 10 = \$400$$

$d^*_5 = kd_k = 5\ [(4{,}000 - 0) / 10] = 2{,}000$ or $5\ (400) = 2{,}000$

$BV_5 = B - d^*_5 = 4{,}000 - 2{,}000 = \$2{,}000$

The depreciation and book value amounts for each year are shown below.

EOY, k	d_k	BV_k
0	-	$4,000
1	$400	3,600
2	400	3,200
3	400	2,800
4	400	2,400
5	400	2,000
6	400	1,600
7	400	1,200
8	400	800
9	400	400
10	400	0

2. Declining Balance (DB) Method

- Sometimes called the *constant percentage method* or the *Matheson formula*.
- It is assumed that the annual cost of depreciation is a fixed percentage of the BV at the beginning of the year.
- The ratio of the depreciation is a fixed percentage of the BV at the beginning of the year is constant throughout the life of the asset and is designated by R ($0 \leq R \leq 1$). In this method, $R = 2/N$ when a 200% declining balance is being used.
- The annual depreciation charges, different each year, decrease from year to year, greatest during the 1st year and least in the last year of life of the property.
- With this method, a property can never depreciate to zero value.

$$d_1 = B\ (R)$$

$$d_k = B\ (1 - R)^{k-1}\ (R)$$

$$d^*_k = B\ [1 - (1-R)^k]$$

$$BV_k = B(1 - R)^k$$

$$BV_N = B(1 - R)^N$$

Rework with sample problem 1 with the declining balance method when $R = 2/N$ (200% declining balance)

Sample computation: with the declining balance method when R = 2/N (200% declining balance)

$R = 2/N = 2 / 10 = 0.20$
$d_6 = 4{,}000\ (1 – 0.20)^5\ (0.20) = \$262.14$
$d^*_6 = 4{,}000\ [1 – (1\text{-}0.20)^6] = \$2{,}951.42$
$BV_6 = 4{,}000\ (1 – 0.20)^{\ 6} = 1{,}048.58$

The depreciation and book value amounts for each year are shown below.

EOY, k	d_k	BV_k
0	-	$4,000
1	800.00	3,200.00
2	640.00	2,560.00
3	512.00	2,048.00
4	409.60	1,638.40
5	327.68	1,310.72
6	262.14	1,048.58
7	209.72	838.86
8	167.77	671.09
9	134.22	536.87
10	107.37	429.50

3. Sum-of-the-Years-Digits (SYD) Method

- It provides very rapid depreciation during the early years of life of the property, and therefore enables faster recovery of capital.
- The basic assumption for this method is that the value of the property decreases at a decreasing rate.
- To compute:
  a) List the digits corresponding to the number for each permissible year of life in reverse order
  b) Determine the sum of these digits
  c) For any year, the depreciation factor is the number from the reversed-order listing for that year divided by sum of the digits.
  d) The depreciation deduction for any year is the product of the SYD depreciation factor that year and the difference between the cost basis (B) and the SV_N.

In general, the annual cost of depreciation for any year k, when N equals the depreciable life of an asset, is:

$$d_k = (B – SV_N) \text{ x } [2\ (N – k + 1) / N\ (N + 1)]$$

The book value at the end of the year k is

$BV_k = B – [2 (B – SV_N) / N] k + [(B – SV_N) / N (N + 1)] k (k + 1)$

And the cumulative depreciation through the kth year is simply

$d^*_k = B - BV_k$

Using SYD method, rework with sample problem no. 1.

Year	No. of the year in Reverse Order	SYD Depreciation Factor
1	10	10/55
2	9	9/55
3	8	8/55
4	7	7/55
5	6	6/55
6	5	5/55
7	4	4/55
8	3	3/55
9	2	2/55
10	1	1/55
Sum of the digits	55	

Sample computation using SYD Factor:

$d_4 = 0.1273 (4,000) = 509.09$

Sample computation using formulas:

$d_4 = 4,000 [2(10 – 4 + 1) / 10 (11)] = \$ 509.09$

$BV_4 = 4,000 – [2(4,000) / 10] x 4 + [4,000 / 10 (11)] x 4x 5 = 1,527.27$

$d^*_4 = 4,000 – 1,527.27 = \$2,427.73$

The depreciation and book value amounts for each year are shown below.

EOY, k	d_k	BV_k
0	-	$4,000.00
1	$727.27	3,272.73
2	654.55	2,618.18
3	581.82	2,036.36
4	509.09	1,527.27
5	436.36	1,090.91
6	363.64	727.27
7	290.91	436.36
8	218.18	218.18
9	145.45	72.73
10	72.73	0

4. **Sinking Fund Method**
   - This method depreciates an asset as if the firm were to make a series of equal deposits whose value at the end of the asset's useful life just equaled the cost of replacing the asset.
   - It is assumed that a sinking fund is established in which funds will accumulate for replacement purposes and will bear interest.
   - The total depreciation which has occurred up to any given time is assumed to equal the amount in the sinking fund at that time.

If A' = sinking fund deposit
C = purchase price of replacement asset – net salvage value of current asset
N = useful life of current asset
i = annual interest rate

then $A' = C\,(A/F, i\%, N)$

The amount in the sinking fund at the end of year k (k = 1,2….N) is the accumulated depreciation through k, thus:

$$\begin{aligned} d^*_k &= A'\,(F/A, i\%, k) \\ &= C\,(A/F, i\%, N)\,(F/A, i\%, k) \end{aligned}$$

The depreciation in year k, which includes interest earned at that time, is given as:

$$\begin{aligned} d_k &= d^*_k - d^*_{k-1} \\ &= C\,(A/F, i\%, N)\,[(F/A, i\%, k) - (F/A, i\%, k-1)] \end{aligned}$$

The book value, BV, as usual is defined as

$$BV_k = B - d^*_k$$

Sample problem 2. A contractor imported a bulldozer for his job, paying P250,000 to the manufacturer. Freight and insurance charges amounted to P18,000; customs, broker's fee, P8,500; taxes, permits and other expenses, P25,000. If the contractor estimates the life of the bulldozer to be 10 years with a salvage value of P20,000 ,tabulate the annual depreciation amounts and the book value of the bulldozer at the end of each year using sinking fund formula at 8%.

$B = 250{,}000 + 18{,}000 + 8{,}500 + 25{,}000 = 301{,}500$
$SV = 20{,}000$

$A' = C\ (A/F, i\%, N)$
$= 301{,}500 – 20{,}000\ (A/F, 8\%, 10)$
$= 281{,}500\ (0.0690)$
$= 19{,}423.50$

$d^*_2 = A'\ (F/A, 8\%, 2) = 19{,}423.50\ (2.0800) = 40{,}400.88$

$d^*_6 = A'\ (F/A, 8\%, 6) = 19{,}423.50\ (7.3359) = 142{,}488.85$

$BV_6 = B – d^*_6 = 301{,}500 - 142{,}488.85 = 159{,}011.15$

$d_6 = C\ (A/F, i\%, 10)\ [(F/A, i\%,6) - (F/A, i\%,6-1)]$
$= 19{,}\ 423.50\ (7.3359 – 5.8666)$
$= 19{,}\ 423.50\ (1.4693)$
$= 28{,}538.95$

or simply: $d_6 = d^*_6 – d^*_5 = 142{,}488.85 - 113{,}949.90 = 28{,}538.95$

The depreciation and book value amounts for each year are shown below.

EOY, k	d_k	d^*_k	BV_k
0	-	-	301,500.00
1	19,423.50	19,423.50	282,076.50
2	20,977.38	40,400.88	261,099.12
3	22,655.57	63,056.45	238,443.55
4	24,467.78	87,524.23	213,975.77
5	26,425.67	113,949.90	187,550.09
6	28,583.95	142,488.85	159,011.15
7	30,823.15	173,312.00	128,188.00
8	33,288.00	206,600.00	94,900.00
9	35,952.89	242,552.89	58,947.11
10	38,827.59	281,380.48	20,119.52

5. Units-of-Production Method

- This method results in the cost basis (minus final SV) being allocated equally over the estimated number of units produced during the useful life of the asset.

Depreciation per unit of production = B – SV_N / Estimated lifetime production in units

Sample problem 3. A piece of equipment used in a business has a basis of $50,000 and is expected to have a $10,000 salvage value when replaced after 30,000 hours of use. Find depreciation rate per hour of use, and find its book after 10,000 hours operation.

Solution:
Depreciation per unit of production = $50,000 – 10,000 / 30,000 = $1.33 per hour

After 10,000 hours, BV = $50,000 - $1.33/hr (10,000 hrs) = $36,700

CHAPTER V, APPLICATIONS OF MONEY-TIME RELATIONSHIPS

METHODS FOR EVALUATING THE VIABILITY OF A PROPOSED PROJECT

1. THE PRESENT WORTH METHOD

- It is based on the concept of equivalent worth of all cash flows relative to some base or beginning point in time called the *present*.
- It is a measure of how much money an individual or a firm could afford to pay for the investment in excess of its cost.
- The criterion for this method in order that a project be economically feasible is that the present worth of the net cash flows be equal to or greater than zero ($PW \geq 0$) .
- To find the PW as a function of i% of a series of cash receipts and/or expenses, use the following relationship:

$$PW(i\%) = F_0 (1+i)^0 + F_1 (1+i)^{-1} + F_2 (1+i)^{-2} + \ldots\ldots\ldots + F_k (1+i)^{-k} + \ldots\ldots\ldots F_N (1+i)^{-N}$$

$$= \sum_{k=0}^{N} F_k (1+i)^{-k}$$

Where i = effective interest rate, or MARR, per compounding period
k = index for each compounding period ($0 \leq k \geq N$)
F_k = future cash flow at the end of period k
N = number of compounding periods in the planning horizon

Sample problem1: An investment of $10,000 can be made that will produce a uniform annual of $5,500 for five years and then have a market (salvage) value of $2,000. Annual expenses will be $3,150 each year. The company is willing to accept any project that will earn 10% per year or more, on all invested capital. Show whether this is a desirable investment by using the PW method.

Solution:

PW	**Cash Outflows**	**Cash Inflows**
Annual revenue: $5,550 (P/A, 10%, 5)		$20,849
$P = \$5,500 \dfrac{(1.1)^5 - 1}{0.1(1.1)^5} = \$5,500 (3.7908)$		
Market (salvage) value: $2,000 (P/F,10%,5)		
$P = \$2,000 (1.1)^{-5} = \$2,000 (0.6209)$		$1,242
Investment		
Annual Expenses: $3,150 (P/A, 10%, 5)		
	-$10,000	
$P = \$3,150 \dfrac{(1.1)^5 - 1}{0.1(1.1)^5} = \$3,150 (3.7908)$	-$11,941	
Total PW		
	-$21,941	$22,091

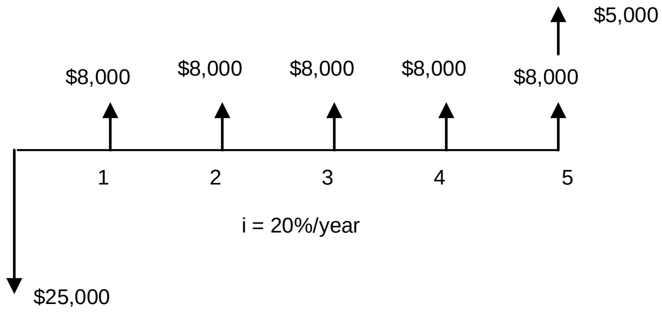
Because total PW (10%) = **$150**, which is > 0, the project is shown to be marginally acceptable.

Sample problem2: An existing machine in a factory has an annual maintenance cost of P40,000. A new and more efficient machine will require an investment of P90,000 and is estimated to have a salvage value of P30,000 at the end of 8 years. Its annual expenses for maintenance and upkeep, etc total is P22,000. If the company expects to earn 12% on its investment, will it be worthwhile to purchase the new machine?

Solution:

PW for existing machine: P40,000 (P/A, 12%,8)
= P40,000 (4.9676) = 198,704
PW for new machine: P90,000 + P22,000 (P/A,12%,8) – P30,000 (P/F,12%,8)
P90,000 + P22,000 (4.9676) – P30,000 (0.4038)
P90,000 + 109,287 – 12,114
P187,173
Thus, it will be worthwhile to invest in the new machine.

Sample problem3: A piece of new equipment has been proposed by engineers to increase the productivity of a certain manual welding operation. The investment cost is $25,000, and the equipment will have a market value of $5,000 at the end of a study period of five years. Increased productivity attributable to the equipment will amount to $8,000 per year after extra operating costs have been subtracted from the revenue generated by the additional production. If the firm's MARR is 20% per year, is this proposal a sound one? Use the PW method.



Solution:

PW = PW of cash inflows – PW of cash outflows

PW (20%) = $8,000 (P/A, 20%, 5) + $5,000 (P/F, 20%, 5) - $25,000
= $8,000 (2.9906) + $5,000 (0.4019) - $25,000
= $23,924.8 + $2009.5 – $25,000
= $934.30

Because PW (20%) > 0, this equipment is economically justified.

1.1 Bond Value

- A bond provides an excellent example of commercial value being the PW of the future net cash flows that are expected to be received through ownership of an interest-bearing certificate. Thus, the value of a bond, at any time, is the PW of future cash receipts.
- A bond is a debt instrument requiring the issuer (also called the debtor or borrower) to repay to the lender/investor the amount borrowed plus interest (coupons) over a specified period of time.
- Owner of the bonds is paid two types of payments by the borrower.
  1. the first consists of the series of periodic interest payments he or she will receive until the bond is retired.
  2. when the bond is retired or sold, the bondholder will receive a single payment.
- The PW of the bond is the sum of present worths of these two types of payments at the bond's yield rate (i%):

$$V_N = C\ (P/F, i\%, N) + rZ\ (P/A, i\%, N)$$

Where: Z = face, or par value
C = redemption or disposal price (usually equal to Z)
r = bond rate (nominal interest) per interest period
N = number of periods before redemption
$i\%$ = bond yield rate per period
V_N = value (price) of the bond N interest periods prior to redemption – this is a PW measure of merit.

Sample Problem4: A bond with a face value of $5,000 pays interests of 8% per year. This bond will be redeemed at par value at the end of its 20-year life, and the first interest payment is due one year from now. How much should be paid now for this bond in order to receive a yield of 10% per year on the investment?

N = 20 years
r = 8% per year
$Z = C$ = \$5,000
$i\%$ = 10% per year

$$\begin{aligned} V_N &= \$5{,}000\ (P/F, 10\%, 20) + \$5{,}000\ (0.08)\ (P/A, 10\%, 20) \\ &= \$5{,}000\ (0.1486) + \$400\ (8.5136) \\ &= \$743 + \$3{,}405.44 \\ &= \$4{,}148.44 \end{aligned}$$

Sample Problem5: A certain U.S. Treasury bond that matures in eight years has a face value of $10,000. This means that the bondholder will receives $10,000 cash when the bond's maturity date is reached. The bond stipulates a fixed nominal interest rate of 8% per year, but interest payments are made to the bondholder every three months; therefore each payment amounts to 2% of the face value.

A prospective buyer of this bond would like to earn 10% nominal interest (compounded quarterly) per year on his or her investment. How much should this buyer be willing to pay for the bond?

r = 2% per quarter

$i\% = 10\%/4 = 2.5\%$ per quarter
$N = 8\ (4) = 32$ quarters
$C = Z = \$10,000$

$$\begin{aligned} V_N &= \$10,000\ (0.02)\ (P/A, 2.5\%, 32) + \$10,000\ (P/F, 2.5\%, 32) \\ &= \$200\ (21.8492) + \$10,000\ (0.4537) \\ &= \$4,369.83 + \$4,537.71 \\ &= \$8,907.54 \end{aligned}$$

2. THE FUTURE WORTH METHOD

- It is based on the equivalent worth of all cash inflows and outflows at the end of the planning horizon (study period) at an interest rate generally the MARR.
- All cash inflows and outflows are compounded forward to a reference point in time called the *future.*
- Criterion: A project is feasible if $FW \geq 0$
- To determine the future worth of a project, the following relationship is used:

$$\begin{aligned} FW\ (i\%) &= F_0\ (1+i)^N + F_1\ (1+i)^{N-1} + \ \ldots\ldots\ldots + F_N\ (1+i)^0 \\ &= \sum_{k=0}^{N} F_k\ (1+i)^{N-k} \end{aligned}$$

Sample problem1: (Same problem in PW). An investment of $10,000 can be made that will produce a uniform annual of $5,500 for five years and then have a market (salvage) value of $2,000. Annual expenses will be $3,150 each year. The company is willing to accept any project that will earn 10% per year or more, on all invested capital. Show whether this is a desirable investment by using the FW method.

Solution:

$$\begin{aligned} FW\ (10\%) &= -10,000\ (F/P,10\%,5) + 2,350\ (F/A, 10\%,5) + 2,000 \\ &= -10,000\ (1.6105) + 2,350\ (6.1051) + 2,000 \\ &= -16,105 + 14,347 + 2,000 \\ &= 242 \end{aligned}$$

Since $FW\ (10\%) > 0$, it is a good project.

Sample problem2: (Same problem in PW) A piece of new equipment has been proposed by engineers to increase the productivity of a certain manual welding operation. The investment cost is $25,000, and the equipment will have a market value of $5,000 at the end of a study period of five years. Increased productivity attributable to the equipment will amount to $8,000 per year after extra operating costs have been subtracted from the revenue generated by the additional production. If the firm's MARR is 20% per year, is this proposal a sound one? Use the FW method.

$$\begin{aligned} FW\ (20\%) &= -\$25,000\ (F/P,20\%,5) + \$8,000\ (F/A, 20\%,5) + \$5,000 \\ &= -\ \$25,000\ (2.4883) + \$8,000\ (7.4416) + \$5,000 \\ &= -\$62,207.5 + \$59,532.8 + \$5,000 \\ &= \$2,325.3 \end{aligned}$$

Since FW (20%) > 0, it is a good project.

3. THE ANNUAL WORTH METHOD

- The AW of a project is an equal annual series of dollar amounts, for a stated study period, that is equivalent to the cash inflows and outflows at an interest rate that is generally the MARR.
- The AW is the annual equivalent revenues (or savings), R, minus annual equivalent expenses, E, less its annual equivalent capital recovery cost, CR.
- Criterion: A project is acceptable if AW ≥ 0
- AW is calculated as follows:

$$AW(i\%) = R - E - CR(i\%)$$

- The Capital Recovery (CR) amount for a project is the equivalent uniform annual cost of the capital invested. It is an annual amount that covers the following items:
  1. Loss in value of the asset
  2. Interest on invested capital (i.e., at the MARR)

CR is computed with i = MARR using the following:

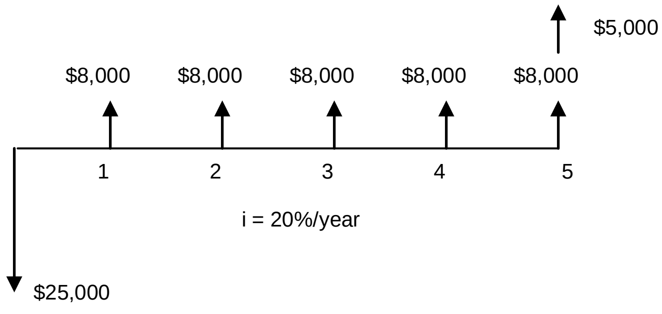
$$CR(i\%) = I\,(A/P, i\%, N) - S\,(A/F, i\%, N)$$

where I = initial investment for the project
S = salvage (residual) value at the end of the study period
N = project study period

As an example, consider a machine or other asset that will cost $10,000, last five years, and have a salvage (market) value of $2,000. The MARR is 10% per year. The CR amount is:

$$\begin{aligned} CR(10\%) &= \$10,000\,(A/P, 10\%, 5) - \$2,000\,(A/F, 10\%, 5) \\ &= \$10,000\,(0.2638) - \$2,000\,(0.1638) \\ &= \$2,638 - \$328 \\ &= \$2,310 \end{aligned}$$

Sample problem1: (Same problem in PW and FW) A piece of new equipment has been proposed by engineers to increase the productivity of a certain manual welding operation. The investment cost is $25,000, and the equipment will have a market value of $5,000 at the end of a study period of five years. Increased productivity attributable to the equipment will amount to $8,000 per year after extra operating costs have been subtracted from the revenue generated by the additional production. If the firm's MARR is 20% per year, is this proposal a sound one? Use the AW method.



Solution:

$$\begin{aligned} AW\,(20\%) &= R - E - CR \\ &= \$8{,}000 - [\$25{,}000\,(A/P,20\%,5) - \$5{,}000\,(A/F,20\%,5)] \\ &= \$8{,}000 - [\$25{,}000\,(0.3344) - \$5{,}000\,(0.1344)] \\ &= \$8{,}000 - (\$8360 - \$672) \\ &= \$8{,}000 - \$7{,}688 \\ &= \underline{\$312} \end{aligned}$$

AW (20%) is positive, the equipment more than pays for itself over a period of five years while earning a 20% return per year on the unrecovered investment.

4. THE INTERNAL RATE OF RETURN (IRR) METHOD

- It is the most widely used rate of return method for performing engineering economic analysis.
- Also known as *investor's method, discounted cash flow method,* and *probability index.*
- This involves solving for the interest rate, termed internal rate of return (IRR), that equates the equivalent worth of an alternative's cash inflows (receipts or savings) to the equivalent worth of cash outflows (expenditures, including investments costs).
- IRR can be defined also as the interest rate that reduces the present worth amount of a series of receipts and disbursements to zero.
- Criterion: A project is acceptable if $i' \geq$ MARR
- By using a PW formulation, IRR is the i% at which

$$\sum_{k=0}^{N} R_k\,(P/F,i'\%,k) = \sum_{k=0}^{N} E_k\,(P/F,i'\%,k)$$

where: R_k = net revenues for the kth year
E_k = net expenditures including any investments costs for the kth year
N = project life (or study period)

- In computing the IRR for an alternative is to determine the i'% at which the net PW is zero.

$$PW = \sum_{k=0}^{N} R_k\,(P/F,i'\%,k) - \sum_{k=0}^{N} E_k\,(P/F,i'\%,k) = 0$$

- Using PW = 0, FW = 0 or AW = 0 normally involves trial and error calculations until the i'% is converged upon or can be interpolated.

Sample problem1: (Same problem in PW and FW) An investment of \$10,000 can be made that will produce a uniform annual of \$5,500 for five years and then have a market (salvage) value of \$2,000. Annual expenses will be \$3,150 each year. The company is willing to accept any project that will earn 10% per year or more, on all invested capital. Determine whether it is acceptable by using the IRR method.

Solution: Notice that the sum of positive cash flows (13,750) exceeds the sum of negative cash flows (\$10,000), so a positive value of i'% can be determined.

PW = 0 = -10,000 + (5,500 – 3150) (P/A, i’%,5) + 2,000 (P/F, i’%,5)

At i’% = 5%: PW = - 10,000 + 2,350 (4.3295) + 2,000 (0.7835) = 1,741

At i’% = 15%: PW = - 10,000 + 2,350 (3.3522) + 2,000 (0.4972) = -1,128

$$\frac{15\% - 5\%}{\$1,741 - (-\$1,128)} = \frac{i'\% - 5\%}{\$1,741 - \$0} = \underline{i' = 11.07\%}$$

Since i’ > MARR (10%), the project is feasible.

Sample problem2: A piece of new equipment has been proposed by engineers to increase the productivity of a certain manual welding operation. The investment cost is $25,000, and the equipment will have a market value of $5,000 at the end of a study period of five years. Increased productivity attributable to the equipment will amount to $8,000 per year after extra operating costs have been subtracted from the revenue generated by the additional production. Evaluate the IRR of the proposed equipment. Is the investment a good one? Recall that the MARR is 20% per year.

PW = 0 = $8,000 (P/A, i’%,5) + $5,000 (P/F, i’%,5) – $25,000

At i’% = 25% = $8,000 (P/A, 25%,5) + $5,000 (P/F, 25%,5) – $25,000
= $8,000 (2.6893) + $5,000 (0.3277) – $25,000
= $21,514.4 + $1,638.5 - $25,000
= -1,847.1

At i’% = 20% = $8,000 (P/A, 20%,5) + $5,000 (P/F, 20%,5) – $25,000
= $8,000 (2.9906) + $5,000 (0.4019) – $25,000
= $23,924.8 + $2,009.5 - $25,000
= 934.3

$$\frac{25\% - 20\%}{934.3 - (-1,847.1)} = \frac{i'\% - 20\%}{\$934.3 - \$0} = \underline{i' = 21.7\%}$$

Since i’ < MARR (20%), the project is not feasible.

Sample problem3: A project is estimated to cost P100,000, lasts 8 years and have a P10,000 salvage value. The annual gross income is expected to average P24,000 and annual expenses, excluding depreciation will total P6,000. If capital is earning 10% before income taxes, determine is this a desirable investment using the IRR Method.

PW = 0 = 24,000 (P/A, i’%,8) + 10,000 (P/F, i’%,8) – 100,000

At i’% = 10% = 18,000 (P/A, 10%,8) + 10,000 (P/F, 10%,8) – 100,000
= 18,000 (5.3349) + 10,000 (0.4665) – 100,000
= 96,028.2 + 4,665 – 100,000

$$= 693.2$$

$$\begin{aligned} \text{At } i\% = 12\% &= 18{,}000\,(P/A, 12\%,8) + 10{,}000\,(P/F, 12\%,8) - 100{,}000 \\ &= 18{,}000\,(4.9676) + 10{,}000\,(0.4039) - 100{,}000 \\ &= 89{,}416.8 + 4{,}039 - 100{,}000 \\ &= -6{,}544.2 \end{aligned}$$

$$\frac{x}{2} = \frac{693.2}{639.2 - (-6{,}544.2)} = \underline{x = 0.19}$$

10% + 0.19 = 10.19%

The project is feasible.

5. THE EXTERNAL RATE OF RETURN (ERR) METHOD

- It directly takes into account the interest rate (ε) external to a project at which net cash flows generated (or required) by the project over its life can be reinvested (or borrowed).
- If the ERR, which is usually the firm's MARR, happens to equal the project's IRR, then the ERR method produces results identical to those of the IRR method.
- Three steps used in calculating procedure:
  1. All net cash outflows are discounted to time 0 (the present) at ε% per compounding period.
  2. All net cash inflows are compounded to period N at ε%.
  3. The external rate of return, which is the interest rate that establishes between the two quantities, is determined.

$$\sum_{k=0}^{N} E_k\,(P/F, \varepsilon\%,k)\,(F/P, i'\%, N) = \sum_{k=0}^{N} R_k\,(F/P, \varepsilon\%,N-k)$$

where R_k = excess of receipts over expenses in period k
E_k = excess of expenditures over receipts in period k
N = project life or number of periods for the study
ε = external investment rate per period

- A project is acceptable when i'% of the ERR method is greater than or equal to the firm's MARR.
- Advantage over IRR : it can be solved directly.

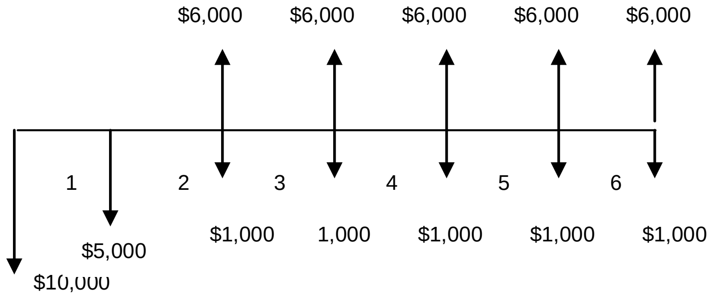
Sample Problem 1. A piece of new equipment has been proposed by engineers to increase the productivity of a certain manual welding operation. The investment cost is $25,000, and the equipment will have a market value of $5,000 at the end of a study period of five years. Increased productivity attributable to the equipment will amount to $8,000 per year after extra operating costs have been subtracted from the revenue generated by the additional production. Suppose that ε = MARR = 20% per year. What is the alternative's external rate of return, and is the alternative acceptable?

Solution:

$25,000 (F/P, i'%, 5) = $8,000 (F/A, 20%, 5) + $5,000
$25,000 (F/P, i'%, 5) = $8,000 (7.4416) + $5,000
$25,000 (F/P, i'%, 5) = $64,532.80
(F/P, i'%, 5) = $64,532.80 / $25,000
(F/P, i'%, 5) = 2.5813
$(1 + i'\%)^5 = 2.5813$
$i'\% = 2.5813^{1/5} - 1$
$i'\% = 20.88\%$

because i' > MARR, the alternative is barely justified.

Sample Problem 2. When ε = 15% and MARR = 20% per year, determine whether the project whose total cash flow diagram appears below is acceptable. Notice in this example that the use of an ε% different from the MARR is illustrated. This might occur if, for some reason, part or all of the funds related to a project are "handled" outside the firm's normal capital structure.



Solution:

E_0 = $10,000 (k =0)
E_1 = $5,000 (k=1)
R_k = $5,000 for k = 2,3,…,6

[$10,000 + $5,000 (P/F, 15%,1)] (F/P, i'%, 6) = $5,000 (F/A,15%,5)
[$10,000 + $5,000 (0.8696)] $(1+i'\%)^6$ = $5,000 (6.7424)
[$10,000 + $4,348] $(1+i'\%)^6$ = $33,712
$14,348 $(1+i'\%)^6$ = $33,712
$(1+i'\%)^6$ = $33,712 / $14,348
$(1+i'\%)^6 = 2.35$
$(1+i'\%) = 2.35^{1/6}$
$(1+i'\%) = 1.15$
$i'\% = 1.15 - 1$
$i'\% = 0.15 = 15\%$

The i'% is less than MARR = 20%; therefore, this project would be unacceptable acceptable according to the ERR method.

6. THE PAYBACK (PAY-OUT) PERIOD

- Often called the simple payout period, mainly indicates a project's liquidity rater than its profitability.
- The payback method calculates the number of years required for cash inflows to just equal cash outflows.
- The simplest payback period is the smallest value of θ ($\theta \le N$) for which this relationship is satisfied under our normal end-of-year cash flow convention.
- For a project where all capital investment occurs at time 0:

$$\sum_{k=0}^{\theta} (R_k - E_k) - I \geq 0$$

- The simplest payback period ignores the time value of money and all cash flows that occur after θ.

Sample Problem:

A piece of new equipment has been proposed by engineers to increase the productivity of a certain manual welding operation. The investment cost is $25,000, and the equipment will have a market value of $5,000 at the end of a study period of five years. Increased productivity attributable to the equipment will amount to $8,000 per year after extra operating costs have been subtracted from the revenue generated by the additional production. If the firm's MARR is 20% per year, calculate the simple payback period.

Calculation of the simple payback period (θ)

Year k	Net Cash Flow	Cumulative PW at I = 0%/yr trough Year k
0	-$25,000	-$25,000
1	8,000	-17,000
2	8,000	-9,000
3	8,000	-1,000
4	8,000	+7,000
5	13,000	+20,000

Θ = 4 years because the cumulative balance turns positive at EOY 4.

- The discounted payback period, θ' ($\theta' \le N$), is calculated so that the time value of money is considered:

$$\sum_{k=1}^{\theta'} (R_k - E_k)(P/F, i\%, k) - I \geq 0$$

where i = is the MARR
I = is the capital investment
θ' = smallest payback period

Calculation of the discounted payback period (θ)

Year k	Present worth of cash flow at i=20%/yr	Cumulative PW at MARR = 20%/yr through Year k
0	-$25,000	-$25,000
1	6,667	-18,333
2	5,556	-12,777
3	4,630	-8,147
4	3,858	-4,289
5	5,223	+934

Θ' = 5 years because the cumulative discounted balance turns positive at EOY 5.

THE BENEFIT-COST RATIO METHOD

- Benefit-cost analysis is a systematic method of assessing the desirability of government projects or policies when it is important to take a long view of future effects and a broad view of possible side effects.
- Involves the calculation of a ratio of benefits to costs.
- The B/C ratio is actually a ratio of discounted benefits to discounted costs.
- For over 60 years, the B/C ratio method has been the accepted procedure for making go/no-go decisions on independent projects and for comparing alternative projects in the public sector.
- The B/C ratio is defined as the ratio of the equivalent worth measure applied can be present worth, annual worth, or future worth.
- It is also known as Savings-Investment Ratio (SIR) by some governmental agencies.
- A project is desirable or acceptable when the B/C ratio is greater than or equal to 1.0.

Conventional B/C ratio with PW

$$B/C = \frac{\text{PW (benefits of the proposed project)}}{\text{PW (total costs of the proposed project)}} = \frac{\text{PW (B)}}{\text{I + PW (O \&M)}}$$

Where: PW = present worth
B = benefits of the proposed project
I = initial investment in the proposed projects
O&M = operating and maintenance costs of the proposed project

Modified B/C ratio with PW

$$B/C = \frac{\text{PW (B)} - \text{PW (O\&M)}}{\text{I}}$$

Conventional B/C ratio with AW

$$B/C = \frac{\text{AW (benefits of the proposed project)}}{\text{AW (total costs of the proposed project)}} = \frac{\text{AW (B)}}{\text{CR + AW (O \&M)}}$$

Where: AW = annual worth
B = benefits of the proposed project
CR = capital recovery amount (i.e., the equivalent annual cost of the initial investment, I, including an allowance for salvage value, if any.)
O&M = operating and maintenance costs of the proposed project

Modified B/C ratio with AW

$$B/C = \frac{AW\,(B) - AW\,(O\&M)}{CR}$$

Conventional B/C ratio with PW, Salvage value (S) included

$$B/C = \frac{PW\,(\text{benefits of the proposed project})}{PW\,(\text{total costs of the proposed project})} = \frac{PW\,(B)}{I - PW\,(S) + PW\,(O\&M)}$$

Modified B/C ratio with PW, Salvage value (S) included

$$B/C = \frac{PW\,(B) - PW\,(O\&M)}{I - PW\,(S)}$$

Sample Problem 1. The city of Bugtussle is considering extending the runways of its Municipal Airport so that commercial jets can use the facility. The land necessary for the runway extension is currently farmland, which can be purchased for $350,000. Construction costs for the runway extension are projected to be $600,000, and the additional annual maintenance costs for the extension are estimated to be $22,500. If the runways are extended, a small terminal will be constructed at a cost of $250,000. The annual operating and maintenance costs for the terminal are estimated at $75,000. Finally, the projected increase in flights will require the addition of 2 air traffic controllers, at an annual costs of $100,000. Annual benefits of the runway extension have been estimated as follows:

$325,000	rental receipts from airlines leasing space at the facility
$ 65,000	airport tax charged to passengers
$ 50,000	convenience benefit for residents of Bugtussle
$ 50,000	additional tourism dollars of Bugtussle

Apply the B/C ratio method with a study period of 20 years and a nominal interest rate of 10% per year to determine whether the runways at Bugtussle Municipal Airport should be extended.

Solution:

Conventional B/C: B/C = PW (B) / [I + PW (O&M)]
B/C = $490,000 (P/A,10%,20) / [$1,200,000 + $197,500 (P/A, 10%, 20)
B/C = $490,000 (8.5136) / [$1,200,000 + $197,500 (8.5136)
B/C = $4,171,664 / ($1,200,000 + $1,681,436)
B/C = $4,171,664/ $2,881,436

B/C = 1.45

Modified B/C: B/C = [PW (B) – PW (O&M)] / I
B/C = $490,000 (P/A,10%,20) - $197,500 (P/A, 10%, 20) / $1,200,000
B/C = $4,171,664 - $1,681,436 / $1,200,000
B/C = 2.08

Conventional B/C: B/C = AW (B) / [CR + AW (O&M)] ; CR (i%) = I (A/P, i%, N) – S (A/F, i%, N)

B/C = $490,000 / [$1,200,000 (A/P, 10%, 20) + $197,000]
B/C = $490,000 / [$1,200,000 (0.1175) + $197,000]
B/C = $490,000 / $141,000 + $197,000
B/C = $490,000 / $338,000
B/C = 1.45

Modified B/C: B/C = [AW (B) - AW (O&M)] / CR ; CR (i%) = I (A/P, i%, N) – S (A/F, i%, N)

B/C = $490,000 - $197,000 / [$1,200,000 (A/P, 10%, 20)
B/C = $293,000 / $141,000
B/C = 2.08

CHAPTER VI COMPARING ALTERNATIVES

BASIC CONCEPTS FOR COMPARING ALTERNATIVES

- Alternatives are called mutually exclusive when the selection of one feasible method or alternative excludes the consideration of any other alternative.
- An engineering economy study must be performed to determine which one to choose among mutually exclusive alternatives and how much capital to invest because of different levels of investment produce varying economic outcomes.
- If the extra benefits obtained by investing additional capital are better than those that could be obtained from investment of the same capital elsewhere in the company at the MARR, the investment should be made. If this is not the case, we obviously would not invest more than the minimum amount of capital required, including the possibility of nothing at all. Stated simply, our rule will keep as much as possible invested at a rate of return equal to or greater than the MARR.

Rule 1. When revenues and other economic benefits are present and vary among the alternatives, choose the alternative that maximizes overall profitability. That is select the alternative that has the greatest positive equivalent worth at i = MARR and satisfies all project requirements.

Rule 2. When revenues and other economic benefits are not present or are constant among the alternatives, consider only the costs and select the alternative that minimizes total cost. That is select the alternative that has the least negative equivalent worth at i = MARR and satisfies all project requirements.

Case 1. Useful lives are the same for all alternatives and equal to the study period.

- The most straightforward technique for comparing mutually exclusive alternatives when all useful lives are equal to the study period is to determine the equivalent worth of each alternative based on total investment at i = MARR. Then for investment alternatives, the one with the greatest positive equivalent worth is selected. And in the case of cost alternatives, the one with the least negative equivalent worth is selected.

1st example involves an investment project situation:

Alternatives A and B are two mutually exclusive *investment alternatives* with estimated net cash flows as shown. Useful life of each alternative is 4 years. The MARR = 10% per year. *Investment alternatives* are those with initial (or front-end) capital investments that produce cash flows from increased revenue, savings through reduced costs, or both.

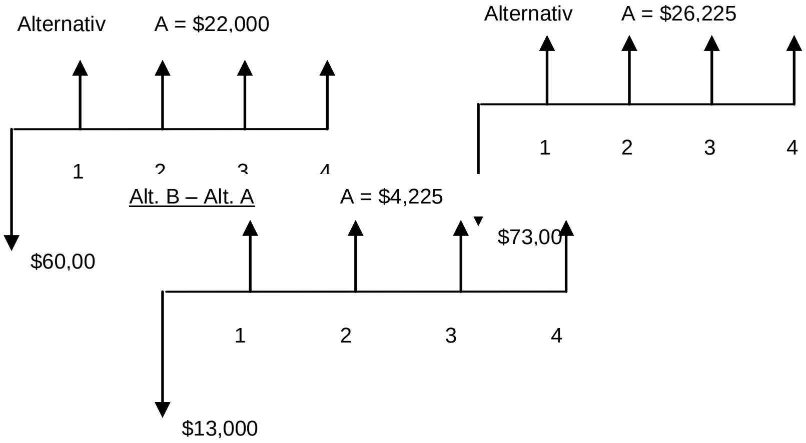
	Alternative	
	A	**B**
Capital investment	-$60,000	-$73,000
Annual revenues less expenses	22,000	26,225

The PW values are:

$PW\ (10\%)_A$ = -$60,000 + $22,000 (P/A,10%,4) = $9,738

$PW\ (10\%)_B$ = -$73,000 + $26,000 (P/A, 10%, 4) = $10,131

Since the PWA is > 0 at i=MARR, it is the base alternative and would be selected **unless** the additional capital associated with Alternative B is justified. In this case, Alternative B is preferred because it has a greater PW value.



The extra benefits obtained by investing the additional $13,000 of capital in B, have a present worth of:

$10,131 - $9,738 = $393

That is, PW (10%)$_{\text{diff}}$ = -$13,000 + $4,225 (P/A, 10%, 4) = $393

And the additional capital invested in B is justified.

2nd example involves a cost project situation:

Alternatives C and D are two mutually exclusive *cost alternatives* with estimated net cash flows as shown over a three-year life. MARR at 10% per year. *Cost alternatives* are those with all negative cash flows except for a possible positive cash flow element from disposal of assets at the end of the projects' useful life. It occurs when the organization must take some action and the decision involves the most economical way of doing it (e.g. the addition of environmental control capability to meet new regulatory requirements).

End of Year	Alternative	
	C	D
0	-$380,000	-$415,000
1	-$38,100	-$27,400
2	-$39,100	-$27,400
3	-$40,100	-$27,400
3[a]	0	$26,000

[a] Market Value

At MARR = 10% per year

PW (10%) C = - $477,077
PW (10%) D = - 463,607

Alternative D is preferred to C because it has the lesser PW of costs. Hence the lower annual expenses obtained by investing the additional $35,000 of capital in Alternative D has a present worth of - 463,607 – (- $477,077) = $13,470. Therefore, the additional capital invested in Alternative D is justified.

Case 2. Useful lives are different among alternatives and at least one do not match the study period.

- When the useful lives of mutually exclusive alternatives are different, the *repeatability assumption* and *co-terminated assumption* maybe used.

  The ***repeatability assumption*** involves two main conditions:
  1. The study period over which the alternatives are being compared is either indefinitely long or equal to a common multiple of the lives of the alternatives.
  2. The economic consequences that are estimated to happen in an alternative's initial useful life span will also happen in all succeeding life spans (replacements)

  The ***co-terminated assumption*** uses a finite (limited) and identical study period for all alternatives. This planning horizon, combined with appropriate adjustments to the estimated cash flows, puts the alternatives on a common and comparable basis.

  Guidelines:
  1. Useful life < Study period
     a. Cost alternatives: contracting for the service or leasing the needed equipment for the remaining years maybe appropriate or repeat part of the useful life of the original alternative, and then use an estimated market value to truncate it at the end of the study period.
     b. Investment alternatives: Assumption used here is that all cash flows will be reinvested in other opportunities available to the firm at the MARR to the end of the study period.
  2. Useful life > Study period: The most common technique is to truncate the alternative at the end of the study period using an estimated market value, that the disposable assets will be sold at the end of the study period at that value.

Sample Problem. The following data have been estimated for two mutually exclusive investment alternatives, A and B, associated with a small engineering project for which revenues as well as expenses are involved. They have useful lives of four and six years, respectively. If the MARR = 10% per year, show which alternative is more desirable by using equivalent worth methods. Use the repeatability assumption.

	A	**B**
Capital investment	-3,500	-5,000
Annual revenue	1,900	2,500
Annual expenses	-645	-1,020

Useful life (years)	4	6
Market value at end of useful life	0	0

Solution:
LCM = 12 years

Alt. A.
PW $_{(10\%)}$ = -3,500 – 3,500 [(P/F, 10%, 4) + (P/F, 10%, 8)] + (1,900 – 645) (P/A, 10%, 12)
= \$1,028

Alt. B.
PW $_{(10\%)}$ = -5,000 – 5,000 (P/F, 10%, 6) + (2,500 – 1,020) (P/A, 10%, 12)
= \$2,262

Based on the PW method we would select Alternative B because it has the larger value.

Suppose that the above problem is modified such that an analysis period of 6 years is used (co-terminated assumption) instead of 12 years.

Solution: Use the FW to analyze the situation.

Alt. A.
FW $_{(10\%)}$ = [-3,500 (F/P, 10%, 4) + (1,900 – 645) (F/A, 10%, 4)] (F/P, 10%, 2)
= \$847

Alt. B.
FW $_{(10\%)}$ = -5,000 (F/P, 10%, 6) + (2,500 – 1,020) (F/A, 10%, 6)
= \$2,561

Based on the FW of each alternative at the end of the six-year stuffy period, we would select Alt. B because it has the larger value.

Imputed Market Value Technique

- Obtaining a current estimate from the marketplace for a piece of equipment or another type of asset is the preferred procedure in engineering practice when a market value at time T < useful life is required.
- The imputed market value technique is sometimes called the implied market value.
- It is calculated based on the sum of two parts as follows:

MV_T = [PW at the end of year T of remaining capital recovery amounts] + [PW at the end of year T of original market value at the end of useful life}

Sample Problem. A piece of production equipment is to be replaced immediately because it no longer meets quality requirements for the end product. The two best alternatives are a used piece of equipment (E1) and a new automated model (E2). Select the preferred alternative with a 5 year study period using the imputed market value technique. The MARR is 15% per year. Select the best alternative using n= 5 years.

	Alternative	
	E1	**E2**
Capital investment	-$14,000	-$65,000
Annual expenses	-14,000	-9,000
Useful life (years)	5	20
Market value at end of useful life	8,000	13,000

Solution:

For Alt. 1

PW = -14,000 – 14,000 (P/A, 15%, 5) + 8,000 (P/F, 15%, 5)
= -14,000 – 14,000 (3.3522) + 8,000 (0.4972)
= -14,000 – 46,930.8 + 3,977.60
= -56,953.2

For Alt. 2

MV_5 = [65,000 (A/P, 15%, 20) – 13,000 (A/F, 15%, 20)] (P/A, 15%, 15)
+ 13,000 (P/F, 15%, 15)
= [65,000 (0.1598) – 13,000 (0.0098)] (5.8474)
+ 13,000 (0.1229)
= (10,387 – 127.4) (5.8474) + 1,597.70
= 59,991.98 + 1,597.70
= 61,589.69

PW = -65,000 – 9,000 (P/A, 15%, 5) + 61.589.69 (P/F, 15%, 5)
= -65,000 – 9,000 (3.3522) + 61.589.69 (0.4972)
= -65,000 – 30,169.80 + 30,622.39
= -64,547.41

Alternative 1 is preferred because it has the least negative equivalent worth at i = 15%

CHAPTER VII. THE FEASIBILITY STUDY

INTRODUCTION

Many years ago, starting, operating and expanding a business was relatively easy than it is today. Business in the past generally involved a smaller amount of capital and started even without an exhaustive investigation regarding its viability. It is mainly, for this reason, why a large number of business projects did not succeed.

Nowadays, business undertakings involved bigger amounts of capital investors are more careful in their investments. So it is not unusual, if, there is an investment or what is known in the financial parlance as the ROI.

Prudence dictates that in the order to minimize risk and to ascertain that a specific project, a thorough study must be first be undertaken. As soon as it is certain that a specific project could be carried out profitability, it is only then that it could be implemented (Ditablan, 1993).

The Nature of Feasibility Studies (Muro, V. 1989)

A project feasibility study sometimes called a project study or feasibility study is an investigation, which ascertains the viability of an undertaking. The undertaking may be new or proposed venture, or existing enterprise. The enterprise may or may not have an expansion program.

A feasibility study is often times a basic requirement for securing a financing or government assistance. Its real objective is to guide project promoters, business promoters, managers, and financial executives in determining the actions they must take on a project in order to bring about its successful operation.

The preparation of a project study involves the following,

1. The collection of data (through research) which are relevant to all aspects of the undertaking.
2. The analyses of the collected data; and
3. The formulation of recommendations, based on the analyses.

PARTS OF A FEASIBILITY STUDY

There are generally five major components of a project feasibility study, namely: Marketing, Technical, Management, Financial and Social Desirability.

Market Study

Generally, investors' are attracted to invest in a business project with a minimal risk and a higher rate of return on investments. However, the major consideration is whether there is an ample demand of the product being produced or proposed to produce. If ample demand exists, find out, if the current producers meet this. In other words, it is first determined whether, there is a substantial excess demand, so that the new firm could enter into the industry. If at the beginning, it is discovered that there is not enough demand for the product or new demand can be created, then, the project must be abandoned.

On the other hand, if the findings indicate that there is a sufficient demand for the product, then investigate the competitive position of the firm in the industry. Here, information on the prevailing prices of the product is gathered and scrutinized. The prices to be adopted for the project and the quality of the product relative to the product of the current and potential producers are also carefully studied. After which the examination of the marketing program follows. The present marketing practices of the competitors, selling organization, terms of sales, channels of distribution, location of sales outlets, transportation and storing facilities and other information relative thereto are also taken into account.

Finally, conclusions are drawn from the study. These specifically identify whether there is an adequate demand for the product and that the project shall enjoy competitive marketing position.

Technical Study

This aspect identifies whether the project could be produced at the highest possible quantity level with a minimum cost. In a manufacturing firm, the items that are taken into consideration are the product itself, the manufacturing process, plant size and production schedule, machinery, plant location and layout, structure, raw materials, utilities, waste disposal and other information deemed necessary in determining technical feasibility.

The composition of the product specifically relating to physical, mechanical and chemical properties is described. This also includes the use of the product.

A very important item in the technical study is the manufacturing process, where the detailed flow-charts indicating materials and energy requirement at each step, and the normal duration of the process are taken into account. In addition, the processes used by the competitors and the process o a combination of processes to be adopted are looked into.

The production capacity of the plant, the number of days the project shall operate per year, the factors determining the plant size and the unexpected attainable yearly production are considered.

Another relevant information of the machinery number, specification, rated capacities of major machinery’s, prices of equipment, and balancing of capacities of each major and auxiliary equipment, availability of spare parts and repair services, including the quotation from suppliers, machinery guarantees, delivery, terms of payments and other arrangements.

Plant location and layout should likewise be considered and studied. Here, it is determined whether the location is desirable in terms of distance to source of raw materials and markets and the other factors. The effect of layout in materials flow and treatment of materials handling and storage including provisions of expansion are taken up. Corollary to this, are the structures to be constructed or rented including the improvements to be done such as roads, drainage facilities and their respective costs.

Facts concerning raw materials are similarly significant. Raw materials are described specifically relating to their physical, mechanical, and chemical properties. Also considered are the alternative raw materials, availability, combination, current and prospective sources and costs.

Finally, utilities and waste disposal are taken into account indicating specific utilities like electricity, fuel, water, supplies and their respective uses, quantity required, balances, availability of sources and costs.

Management Study

Basically, the objective of the feasibility study is to determine the appropriate business organization, the people who will be involved both before and during the operating periods of the enterprise, and then functions.

This answer how the project shall be managed before and during the operating periods, pointing out the firms of persons involved or to be involved in studying the different aspects of the project the type of business organization, organizational chart and function of each unit management personnel, skills and members of labor required specifying the duties and time to be devoted to the project, qualifications, compensations, fringe benefits and facilities.

The recruitment and training programs of personnel as well as the status and timetable of the project are taken into consideration.

Actually, the studies on the plant capacity and location are not purely engineering in nature. For instance, a small or slow-growing market may limit the rated capacity. On the other hand, the location may have to be near the source of materials and also to the market centers.

Financial Study

This portion determines the profitability level of the project which is generally defined as the relationship of the net income after taxes to the total investment. It is largely based on the availability opportunity cost in particular period of time, and place.

The financial study also involves a thorough coverage of all the monetary information of the enterprise. It covers detailed information of the total project cost, initial capital requirements, sources of financing, financial statements and financial analysis.

Included in the total project cost and the initial capital requirements, are all the items considered and the assumptions made.

Identification of sources of financing is likewise an essential element of the feasibility study indicating the currency, security, repayment period, interest and other features. This also show the status of financing from each source relating to actual release already made, application already approved, applications pending and applications still to be made including information on how to the contingencies and seasonal peaks in working capital shall be financed.

The financial health of the business is assessed in the financial statements and the analysis showing the three important accounting statements such as income, cash flow and the balance sheets. Pertinent financial ratios are also illustrated describing the over-all firm liquidity, degree of indebtedness and profitability. Additional information are also provided such as break-even outputs, sales and prices, amount of sales required to earn a certain amount of profit and the cash payback period.

Financing Aspects. The cash requirements and financing leverage of the firm on one hand, and the investment policies of financial institutions on the other hand, should be thoroughly weighed. The purpose of thus is to obtained adequate financing on the most reasonable terms.

Financial Projections/Estimates. The selection of the management, marketing, technical, and financing specifications is based on mainly on their effects on the profitability and cash estimates, which are covered in the financial projections.

Profitability is the relationship between the capital required to be invested in the project and the profit, which can be generated by such project. For a project that is has an investment of 500,000 and expected to generate an annual profit of 100,000 – the rate of return on investments (ROI) is 500,000/100,000 or 20%. The ROI correlates two sets of figures- the investment required by the project and the series of cash, which the project generates.

Socio-economic Study

The may be classified as a government or a private project. To a government project, socio-economic desirability is given first importance and profitability only comes secondary. As such, feasibility means socio-economic desirability.

The private entity on the other hand, ha reserved priority, that is, profitability comes first and socio-economic desirability only comes secondary. Thus, feasibility is synonymous with profitability.

In both ways, however, socio-economic desirability is measured in terms of the number of workers that shall be employed, and the appropriate annual amount of taxes to be paid by the project and the workers of the government. In addition, it is measured by the economic benefits that will accrue to the people living in the community and its vicinities.

Social Desirability. From the viewpoint of government, economic or social planners, feasibility means social desirability. Thus, a 30-km road, connecting an agricultural country with a shipping port costing of P10, 000,000 may be considered feasible if the road will result in substantially more production in the area, given more profits to farmers and drastically reduce the selling prices of commodities in the areas. Social desirability in the relationship between the benefit to be obtained from the undertaking (i.e. increase in food production, etc.) and the cost of such undertaking.

Taxation and Legal Aspects

The taxation study attempts to design the project in such a way that the tax liabilities of the project and its proponents are legally minimized. The legal aspects affecting, the project or industry are studied.

Preparing the Feasibility study

Feasibility studies may be prepared through various approaches depending on individual preferences. Some give more weight to ocular observations without quantitative and qualitative verifications of the market and the other factors considered in starting or expanding a business enterprise. This is particularly true in case of small-scale industries. However, bigger firms, which are more careful in their investments, use the combination of a “gut feel” and the verifications of the feasibility of all the aspects of a project study in a scientific survey.

For the beginners, the suggested steps to follow on how to prepare a feasibility study are.

1. Identify the people or firms that will be involved in preparing the various aspects of the study.

2. Investigate the market feasibility in terms of both ocular observations and the actual scientific survey. Feasibility here generally means ample excess demand and a competitive market position of the project. If not feasible, abandon the idea immediately before much loss will be incurred, and think of another business project.

3. If market is feasible, proceed with the technical study. Technical feasibility is commonly understood to mean the sources required are available on a long term basis and at a reasonable cost to produce the product at the best possible quality acceptable to the consumers. If not feasible, abandon the project.

4. If technically feasible, proceed with the management study. Management feasibility means that the organizational set-up can carry out its functions effectively and that qualified persons under circumstances are available. If not feasible, abandon the project.

5. If management feasible, proceed with the financial study. Financial feasibility means that the financing shall be able available at a reasonable cost and that the project shall enjoy a good financial support and is deemed profitable.

6. In a case of a government project, the next step is assessment of the social desirability of the project, which means that reasonable economic benefits will accrue to the people living in the community and its vicinities, otherwise, give up the project.

7. Finally, prepare the summary of the feasibility study indicating among others, a brief description of the project; the highlights of major assumption made, such as market projections, share and prices, investment costs, method of financing, etc.; and the summary of findings and conclusions regarding market feasibility, technical feasibility and financial feasibility.

Philippine Projects which Failed

Industry	Cause(s)	Effects on business
Chemicals	undetected pressure of superior competing product	abortion of project
Ceramics	failure to perfect the manufacturing process	foreclosure of mortgaged machinery
Cement	unforeseen high moisture constant of raw materials	purchase of additional machinery
Pulp and Paper	unexpected high cost of gathering raw materials	unprofitable operations
Agriculture	Legal complication in the projected leases of agricultural land.	abortion of project
Real estate	legal contract with the wrong government entity	abortion of project
Ceramics	understated financing requirements	delay in the start of the operation

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APPENDIX B.

B.1 GUIDELINES FOR THE PREPARATION OF PROJECT FEASIBILITY STUDIES

Marcelo M. Roguel*

I. SUMMARY OF THE PROJECT

- A. Name of the firm:
- B. Location:
    - Head office
    - Plant Site
- C. Brief description of the Project
- D. Highlights of major assumptions such as market projections, share and prices, investment costs, methods of financing, etc.
- E. Summary of the findings and conclusions regarding the following
    1. Market feasibility
    2. Technical feasibility
    3. Financial feasibility

II. GENERAL INFORMATION

- A. Management of the Project

    1. Management during the pre-operating period (firms of persons involved or to be involved in marketing, engineering and other studies).

    2. Management during the operating period (type of business organization; organization chart and functions of each unit; management personnel specifying the duties and the time to be devoted to the project, qualification and compensation).

    3. Labor (skills required; number required for each skill; recruitment and training program; compensation, fringe benefits and facilities).

    4. Professional firms or consultants to be hired, if any.

- B. Status and Timetable of the Project
- C. Other information (e.g., pending litigations, information regarding intangibles, etc.)

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III. ECONOMIC ASPECTS

A. Market Study

1. Demand
    a) Consumption for the past ten (10) years. Also, state the major consumers of the products.
    b) Projected consumption for the next ten (10) years. Indicate method used and factors considered in preparing the projections.

2. Supply
    a) Supply for the last ten (10) years, broken down as to the source; whether imported or locally produced.

    For imports, specification should be made as the form in which the goods are imported, the country of origin and the brands.

    For locally produced goods, the companies producing them, their production capabilities and brands used shall be specified.

    b) Projected supply for the next ten (10) years.
    c) Factors affecting trends in fast and future supply.

3. Competitive position considering imported and/or substitute products
    a) Selling Prices- prices to be adopted including tariff protection assumed or expected for the project.

    For products to be sold locally, comparison with prevailing prices (both local and imported) and with prices substitute products; either wholesale or retail which ever is applicable in the light of the applicant firm's marketing program.

    For products to be exported, comparison with landed cost of goods from other countries at the prospective importing country, and with prevailing prices thereat; either wholesale or retail whichever is applicable.

B. Marketing Program

1. Description of the present marketing practice and competitors.

2. Proposed marketing program of the project describing the selling organization, terms of sale, channels of distribution, location of sales outlets, transportation and warehousing arrangements and their corresponding costs.

3. Promoting and advertising plan, including costs.

    4. Packaging.

C. Projected Sales
    1. Expected annual volume of sales for the next ten (10) years considering the demand, supply, competitive position and marketing program.

    2. Sales contracts, if any.

D. Contribution to the Philippine Economy
    1. Net annual amount of dollars earned or saved, after subtracting for: amortization of imported capital equipment; and nay importation of raw materials.
    2. Labor employed and taxes paid.

IV. TECHNICAL FEASIBILITY

A. Product (s)

    1. Description of the product(s) including specifications relating to their physical, mechanical and chemical properties.
    2. Uses of the product(s).

B. Manufacturing Process

    1. Description of the process showing detailed flow charts indicating material and energy requirements of each step; and the normal duration of the process.
    2. Licensing agreement, if any, including terms.
    3. Alternative processes considered and factors used in determining the process to be employed.
    4. Processes used in existing plants and in similar projects in the Philippines or abroad.

C. Plant Size and Production Schedule
    1. Rated annual and daily plant capacity at a given number of operating days per year; and

    2. Expected attainable annual production volume for the next ten (10) years, considering start-up and technical factors.

D. Machinery
    1. Machinery layout, showing the number of specifications, rated capabilities, and balancing of capabilities of each major and auxiliary equipment, and standby units.

2. Availability of spare parts and repair service.
3. Quotations from suppliers, machinery guarantees, delivery, terms of payments and other arrangements.

E. Plant Location
    1. Location map showing plant location.
    2. Desirability of locations in terms of distance to sources of raw materials and markets and other factors.

F. Plant Layout
    1. Description of the plant layout; layout chart.
    2. Effect of the layout on materials flow and treatment of materials handling and storage.
    3. Provisions of expansion.

G. Structure
    1. Building and costs of creation.
    2. Other structures and their respective costs.
    3. Land and improvements such as road, drainage facilities, etc., and their respective costs.

H. Raw Materials
    1. Description and specifications relating to their physical, mechanical and chemical properties.
    2. Alternative raw materials considered and factors used in selecting the raw materials.
    3. Material balance.
    4. Availability, continuity of supply and current prospective sources.
    5. Current and prospective costs of raw materials; terms of any long-term contracts.

I. Utilities

Electricity, fuel, water, stream and supplies specifying the users, quantity required, balance of utilities, availability, sources and alternative sources and costs.

J. Water Disposal
    1. Description and quantity of the waste to be disposed of.
    2. Description of the waste disposal methods.
    3. Methods used in other plants.
    4. Costs of waste disposal.
    5. Clearance from proper authorities or compliance with legal requirements.

V. FINANCIAL FEASIBILITY

A. Total Project Cost- All items considered and assumptions made.
B. Initial Capital Requirements- All items considered and assumptions made.
C. Sources of Financing

1. Sources selected or proposed for both long-term and short-term financing.
2. Alternative sources considered.
3. Amount and terms of financing for each source selected indicating the currency, security repayment period, interest and other features.
4. Status of financing from each source relating to actual release already made, application already approved, applications pending and application still to be made.
5. Financing of contingencies and seasonal peaks in working capital.

D. Financial Statements

1. projected income statements for 10 years
2. Projected cash flow statements for 10 years

3. Projected balance sheets for 10 years.

NOTE: These financial statements shall be made in two (2) sets, viz:

a. One set assuming registration and the enterprise availing of the incentives provided for in R. A. 5186, and
b. One set not assuming registration.

E. Financial analyses (to be done for both sets of financial statements describe above).

1. Unit cost estimates and detailed breakdown of all cost factors from first year until normal operation is attained.
2. Break-even point analysis.
3. Capital recovery and earnings showing the cash payoff period, rate of return and discounted cash flow rate of return.
4. Others

NOTE: For purpose of computation, it is suggested that the foreign exchange obligations be reflected at the rate of P6.50 to $1.

B.2 COMPONENTS OF A PROJECT FEASIBILITY STUDY

By

Eduardo G. Marzan, Jr.
Alma M. dela Cruz*

INTRODUCTION

There are five components of a project feasibility study (PFS) discussed in this paper, namely, management, marketing, technical, financial, and socio-economics. The parts of each component are presented to serve as guide in the preparation of a feasibility study but no detailed discussion or calculations are included.

The components and its sub-components may vary with the type of the project being studied. The paper attempts to show the most common parts of a feasibility study.

COMPONENTS OF A PROJECT FEASIBILITY STUDY

Management Study

Its aim is to have an organization that will effectively carry out the objectives of the proponents. It encompasses the organization for the pre-operating period as well as for the commercial operations. It also includes the forms of business organization, ownership, organizational structure, and personnel requirements.

A. Pre-operating Period

A project organization is required from the conception of a project up to the start of the normal operations. During the pre-operating period, a number of studies and decisions need to be made such as production process, sources of financing, distribution channels, plant capacity, acquisition of plant site and machinery, selection and hiring of consultants, availability of construction materials and workers, among others.

Project scheduling is included under the pre-operating period. It refers to the identification and analysis of the activities from the planning stage up to the start of the normal operations. Either the Gantt chart or the Program Evaluation and Review Technique (PERT) may be used. The Gantt chart shows the various activities and the duration of each activity. The PERT is a more complicated way of scheduling. It shows the activities that can be done simultaneously, the activities that would precede the others, and the activities, which can be hastened in order to advance normal operations

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B. Forms of Business Organization

The proponents may select any one of the alternative forms: single proprietorship, partnership, cooperative and corporation. The selection of the form of business organization may be influenced by the following factors:

1. control of management;
2. attraction of financing;
3. maintenance of good business relations;
4. protection of business secrets;
5. increase in profits through avoidance of taxes;
6. limitations of liabilities of owners; and
7. legal requirements

C. Ownership

The ownership of a project should meet all the legal requirements as to the percentage of Filipino ownership in the business organization

If the corporate form of the business organization is decided upon, the Filipino participation in the ownership should be in consonance with the legal requirements. If the legal requirements are set, the project may be able to:

1. exist;
2. sell to the Philippine government;
3. obtain tax exemption privileges; and
4. obtain government financing

For example, industries using natural resources- agricultural, timber, mineral lands of the public domain- 60 percent of the owners must be Filipinos.

The law provides for minimum Filipino directors in corporation in selected industries as:

1. Commercial banks – 2/3
2. Investment companies – 100%
3. Private development banks – 2/3
4. Rural banks – 100%

D. Organizational Structure

The organizational structure refers to the various departments and sections of a project, their specific functions and their relationships to each other. In planning the structure, the following have to be considered:

1. The basic objective of the project;
2. The nature and extent of operations of the project; and
3. The form of business organization and the ownership structure.

The organizational chart can be divided by function, by geographical area, or by product line.

E. Personnel

The personnel requirements in terms of position titles, qualifications, and number personnel may be based on the organizational chart.

The sources of managers should be identified, including skilled and unskilled workers. The compensation, cash and non-cash benefits should be specified. Policies on bonuses, leaves and overtime pay, SSS premiums, insurance, etc. should be also being explicitly indicated in the study.

Marketing Study

Its objective is to determine the:

1. size, nature, and growth of total demand for the product;
2. supply situation and the nature of competition;
3. price of the product to be sold; and
4. appropriate marketing program to be adopted in order to sell the given quantity at the given price

A. Demand

Demand may be considered as equivalent to the sales quantity, consumption or usage. Data on the past demand may be used in demand projections.

1. Past demand
    - Consumption
    - Past consumption, data may be obtained directly from the consumers or from firms through surveys.
    - Importations
    - Importation data may be obtained from the Central Bank, the NEDA, and the Bureau of Customs.
    - Local Production
    - Data for local production may be obtained from the Central Bank, the NEDA, trade associations, and manufacturers.

2. Projected demand

    Future demand may be based on past demand or from other factors related to the product being studied such as the demand for textiles or food based on population. The projection methods that could be used are;

    Arithmetical Straight Line $Y_c = a + Y_{i-1}$

    Where: $a = \underline{Y_f - Y_1}$

n-1

Y_1 = initial value (first year)
Y_f = final value (last year)
N = No. of years
Y_{i-1} = value of the year past
Y_c = calculated demand

Arithmetic geometric curve $Y_c = Y_{i-1}(1-r)$

Where: $r = \frac{\text{sum of the \% yearly increase}}{n-1}$

r = is average rate of increase
Statistical straight line $Y_c = a + bx$

Where a & b are constant
X – year

Statistical geometric curve

$\text{Log } Y_c = \text{Log } a + x \log b$

Statistical Parabolic

$Y_c = a + bx + cx^2$

The method that gives the computed value that approximates the actual historical demand maybe said to be the most appropriate method to the project further demand. In other words, the method that shows the least standard deviation (actual-computed values) maybe considered the best among the different projection methods.

The projected values could be adjust if there understatements of historical demand figures or increase usage of products. The calculated values could also be compared with the projections of other groups such as the NEDA, Central Bank, Department of Agriculture or other related agencies.

B. Supply

The supply is the total product being sold (including its substitutions) in the market, coming from importations and local production. The local production is then allocated among the local firms, including the new project, to ascertain the project's market share.

A projection on the competing products, importations and local production is also required. Future importations may be estimated not with statistical projections but by the "feel" of the industry.

The allocation of local supply among the various competitions may be based on the:

relative strength of the competitors – rated capacity and production volume, location, management capability and ownership;

1. prices set by the competitors; and
2. marketing program of the competitors

C. Prices

The selling price per unit to be adopted by a project may be determined based on:

- cost of importation;
- cost of production of local competitors
- cost of production of the project;
- cost of transportation; and
- prices at the different levels of the distribution channels

D. Marketing Practices and Program

This part of the study present the marketing mixes that could be used by the project to influence its markets or customers. It is considered the 4P's of marketing – products, place, promotion, and price.

The proponents have to decide their competitive marketing strategy based on their market share and its long-run customer and profit objectives in a particular competitive environment.

Product	Place	Promotion	Price
Quality	Channels	Advertising	List price
Features	Coverage	Personal selling	Discounts
Style	Locations	Sales promotion	Allowances
Brand name	Inventory	Publicity	Payment period
Packaging	Transport		Credit terms
Sizes			
Services			
Warranties			
Returns			

TECHNICAL ASPECT

1. Describe products to be produced indicating specifications relating to their physical, chemical and/or agronomic properties, whichever applicable. Specify by-products resulting from the operations.

2. Describe processes and/or production methods, showing detailed flow chart. Specify maintenance and other support facilities proposed, and quality control and requirements for the processes adopted.

3. Specify major machinery and equipment requirements. Indicate:

    a. Number, specifications, rated capacities and life of major pieces equipment, whether new or second-hand, allocated to the categories according to major use (e.g. production maintenance, waste disposal, etc.). Outline function to be performed by each major unit.

    b. Quotations from suppliers, machinery guarantees, delivery and payment terms and other arrangements. Indicate also supplier, country or port of origin, taxes, duties, installation cost and allowances for minor equipment, etc.

    c. Is equipment to be exclusively used for the production of the products specified? If not, specify to what extent equipment will be used for other purposes.

4. Indicate location/site where the project is to be situated. Make plans and drawings of major structure physical layout of site and plant and machinery layout indicating also provisions for expansion. Enclose cost quotations for land and major structures.

5. Specify rated annual and daily capacity of plant at a specified number of shifts per day and numbers of operating days per year. Give also the expected attainable annual production volume of each product for the entire projects life.

6. Show volume and value of material inputs per unit output (and the respective wastage factors, if applicable) for each product to be produce. Give details of prospective sources of major inputs, consignment arrangements, supply, contracts, etc.

7. Specify special requirements and costs for electricity, water and other utilities.

8. Give detail total labor requirements from start of operations until normal production capacity is attained.

    Also:
    Indicate number of workers according to skill, sex , and whether full time/part time/seasonal, at normal production capacity.

    a. Specify wage rates, salaries, fringe benefits, etc. assumed.
    b. Justify foreign personnel involved. If any.
    c. Set out details of special training programs, including costs.

9. Implementation and operation schedule.

FINACIAL ASPECTS

1. Specify sources if financing whether short-term, long-term and supplier's credit and their respective uses. Also, indicate amount and terms of financing from each source selected, indicating currency, security, repayment, period. Interest and other features. For equity, financing, indicate subscription made.

2. Prepare the following statements for the first 5-10 years of project's life.
    Profit and loss (or Income) statements
    Cash Flow statements
    Balance Sheet statements
    The assumption underlying these projections should be outlined.

3. The following financial evaluations are to be derived based on the information contained in the above statements.
    profitability ratios
    liquidity ratios
    solvency ratios
    break-even analysis
    measures of project worth

SOCIO-ECONOMIC ASPECT

1. Describe the specific contributions of the project on following;

    a. Government Revenues
        ⇒ taxes to be paid by the project
        ⇒ import taxes

    b. Foreign Exchange Reserves

        ⇒ earnings from exports
        ⇒ savings on imports
        ⇒ foreign exchange cost

    c. Related industries

c.

        ⇒ suppliers of raw materials
        ⇒ suppliers of essential utilities/services
        ⇒ processors or users of the product

    d. Consumers

        ⇒ lowering of price

    e. Employment

        ⇒ number of persons to be employed
        ⇒ total wage bill

f. Utilization of local materials

g. Development of the community

h. Raising of the Standards of Living

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B. 3 PROJECT STUDY PREPARATION: DATA NEEDS AND RESOURCES

BY

MARCELO M. ROGUEL

Outline of Data Sources and End Products for Each Step in Feasibility Analysis:

Step	Sources of Data	End Product
1. Market Demand	Demand studies; Market Analysis	Sales potential price
2. Material Supply	Supply Studies Competitive demand	Procurement potential & prices
3. Supply of Other inputs	Supply studies Competitive demand	Available Supply & unit price
4. Capital Cost Estimates	General Design; quantities & unit Price	Investment schedule
5. Added crop Income	Agric. Research & local surveys	Schedule of added net income from crop
6. Production Requirements	Technical Input-output coefficients	Schedule of input & outputs by products
7. Operating Costs	Inputs schedules & unit price	Schedule of combined operating Costs
8. Operating Revenue	Output schedules & unit prices	Schedule of net project benefit
9. Economic Analysis	Investment and benefit schedule	IRR and feasibility of project